PRE-FILED TESTIMONY
OF LLOYD MORGAN
MPUC Docket No. 2011-00262

Q. Please state your name and business address.

A. My name is Lloyd Morgan. My Address is:

2022 Francisco Street
Berkeley, CA 94709

Q. Briefly state your occupation, educational background and current employment.

A. I am an electronic engineer with a BS in Electronic Engineering (UC Berkeley)
Senior Research fellow, Environmental Health Trust (EHT);
Senior Advisor, Radiation Research Trust;

Attached as Exhibit A is my *curriculum vitae.*

Q. Are you a member of any professional organizations? If so, please list.

A. I am a member of the following organizations:
Bioelectromagnetics Society (BEMS);
Brain Tumor Epidemiology Consortium (BTEC);
Environmental Health Trust (EHT);
Central Brain Tumor Registry of the United States (CBTRUS)

Q. Have you authored any papers or journal articles?

A. Yes. A full list is shown on my *curriculum vitae* attached as Exhibit A.

Q. Briefly describe your work and experience related to the study of health risks related to electromagnetic fields and radio frequency waves in the 30 MHz to 300 GHz range ("RF"). Identify any studies or published writings on the subject.

A. My work in the field of bioelectromagnetics (the biological effect from exposure to electromagnetic radiation) began in 1995 after I asked my neurosurgeon, "Why did I get this brain tumor?" He responded, "Perhaps electromagnetic fields." As a trained engineer I went to the science literature and almost immediately found many papers reporting a significant risk of brain tumors and leukemia from Extremely Low Frequency (ELF) magnetic fields including electrical utility industry funded studies.

From 1995 to the present I have attended from 2 to 4 scientific meetings each year. The meetings I attended included:

a. Electric and Magnetic Fields Research and Public Information Dissemination (EMF-RAPID),
b. Bioelectromagnetics Society (BEMS),
c. Brain Tumor Epidemiology Consortium (BTE,
d. Society for Neuro-Oncology (SNO),
e. American Public Health Association (APHA),
f. American Academy of Environmental Medicine (AAEM) and,
g. International Society of Environmental Epidemiology (ISEE)

Over the years I have published various peer-reviewed science papers, had multiple Letters to the Editor accepted by science journals, provided testimony to various bodies, and issued reports and commentaries (see Exhibit A).

Q. Are you familiar with peer-reviewed epidemiological studies addressing the risk of cancer, disease, or other adverse health effects resulting from the exposure to RF?

A. Please note: RF, radio frequency, is *an engineering term without reference to biological effects*. The RF frequency range is from 3 kHz-300 GHz. Another

engineering term, ELF, extremely low frequency, ranges from >0Hz to 3 kHz. Both RF and ELF radiation have been classified as possible carcinogens by the World Health Organization's, International Agency for Research on Cancer (IARC). Cellphones, cordless phones, smart meters, cell towers (cellphone base stations), Wi-Fi, and radar emit microwave radiation (MWR) frequencies all fall within the range of RF radiation.[1]

Yes, I have carefully reviewed every epidemiology study that I am aware of on the risk of exposure from cellphone radiation and many of the studies on the risk from exposure to electricity fields.

Q. Have some of the studies involved exposure to MWR in or near the 2.4 GHz range?

A. Yes. A number of studies involving exposure to microwave radiation in that range have shown adverse health risks from exposure to non-thermal (no measurable temperature increase) MWR. Some of them are included in the list attached as Exhibit B.

Q. Have you performed any studies or meta-analyses of different studies on the subject? Briefly describe the studies and the conclusions.

A. I participated in the cellphone meta-study, "Hardell L, Carlberg M, Söderqvist F, Mild KH, Morgan LL. Long-term use of cellular phones and brain tumors: increased risk associated with use for >10 years. Occup Environ Med. 2007 Sep;

[1] Cellphone radiation and smart meter radiation are in the microwave range (200 MHz-300 GHz), which are within the radio frequency range.

64(9):626-32. Epub 2007 Apr 4" which concluded, "Results from present studies on use of mobile phones for >10 years give a consistent pattern of increased risk for acoustic neuroma and glioma. The risk is highest for ipsilateral exposure." An acoustic neuroma is a tumor on the acoustic nerve. A glioma is a cancer of the glial cells in the brain.

I was the sole author of a study, "Estimating the risk of brain tumors from cellphone use: Published case–control studies. Pathophysiology. 2009 Aug;16(2-3):137-47. Epub 2009 Apr 7" which concluded in part, "The industry-funded Interphone study has assured the public there is no risk of brain tumors from cellphone use. Yet, a closer analysis of the data leads to the incredulous conclusion that cellphone use *protects* the user from brain tumors ($p = 6.2\times10^{-20}$).[2] A more likely explanation of the data is that the Interphone studies were flawed and that there is a link between cellphone use and brain tumors. The Swedish team studies [led by Dr. Lennart Hardell], independent of industry funding, have reported increased brain tumor risk from cellphone use and cordless phone use."

I was a co-author with Dr. Sam Milham on an occupational study of teachers in a small California middle school, "A New Electromagnetic Exposure Metric: High Frequency Voltage Transients Associated With Increased Cancer Incidence in Teachers in a California School"(Am J Ind Med. 2008 Aug;51(8):579-86. doi: 10.1002/ajim.20598.) The "high frequency transients

[2] p is the probability that a result is due to chance. In the example there was one time out of 6 trillion that this would be a chance finding. In other words, it is very, very close to certainty.

were in the RF range. Some of the results we reported were, "Sixteen school teachers in a cohort of 137 teachers hired in 1988 through 2005 were diagnosed with 18 cancers. The observed to expected (O/E) risk ratio for all cancers was 2.78 (P=0.000098), while the O/E risk ratio for malignant melanoma was 9.8 (P=0.0008). Thyroid cancer had a risk ratio of 13.3 (P=0.0098), and uterine cancer had a risk ratio of 9.2 (P=0.019)."

I was a co-author with Örjan Hallberg in a study, "The Potential Impact of Mobile Phone Use on Trends in Brain and CNS Tumors, J Neurol Neurophysiol 2011, S5" whose results found: DNA brain cell damage has an average latency time of over 30 years before increased brain cancer rates would be expected. Mobile phone use may lead to a reduced DNA repair function resulting in about a 2-fold increase in brain cancer incidence, or with an increasing rate of initial DNA brain damage from mobile phone use a 25-fold increase in brain cancer incidence may result.

I was a listed author on a study, "Scientific Panel on Electromagnetic Field Health Risks: Consensus Points, Recommendations, and Rationales." *See* Exhibit G. I was a member of the panel which included experts from Greece, Russia, Sweden, Israel, and the United States. After an extensive review of the literature we made various recommendations for new exposure limits. It concluded:

> We have shown that children and small adults absorb significantly more cell phone radiation than SAM estimates. Accordingly, contemporary cell phone standards for all of the world's more than five billion cell phones do not protect the young or the 97% of the population with heads smaller than SAM. Until SAR standards have been revised, Israel (Azoulay and Rinat

2008), Finland (YLE.fi 2010), France (Lean, 2010), India (India eNews, 2008), and the U.K (BBC, 2000) recommend limited use by children, using wired headsets, hands-free kits, texting, and keeping the mobile phone away from the head and from the body to substantially lower exposures with current cell phones.

Q. What is your opinion about the state of the epidemiological evidence relating to the association between brain cancers from long-term exposure (more than 10 years) to cell phone MWR?

A. Given the World Health Organization's finding of a possible carcinogen combined by the number of human epidemiology studies finding more than a doubled risk of brain cancer after 10 or more years of cellphone use, and with multiple animal and human cell line studies that report DNA damage, my opinion is that the scientific evidence is clear. There is a clear link between long-term microwave radiation exposure and cancer.

Q. Have you reviewed the joint testimony of William H. Bailey, Ph.D. and Yakov Shkolnikov, Ph.D., dated September 19, 2012, in this case?

A. Yes. My first reaction was to note that Exponent witnesses on behalf of the industry clients are well-known for their effective techniques of distorting the scientific evidence to create doubt about safety concerns in the service of their industry clients. I believe William H. Bailey has testified on behalf of his employer Exponent Inc. in many disputes defending utilities and other industry clients. In his book *Doubt Is Their Product, How Industry's Assault on Science*

Threatens Your Health, David Michaels,[3] cites Exponent and their techniques of distortion eleven times. It is one of many "product protection firms" serving industry. Their standard approach is to rely on inconsistencies in the science to create doubt that a product has adverse effects.

In addition to using scientific uncertainty to create doubt, Exponent also uses words and phrases that put industry in the best light. In his testimony, Dr. Shkolnikov continually refers to "RF energy" instead of RF radiation. The industry previously used the phrase "RF radiation," but realizing that "radiation" is an undesirable word, industry has now adopted the sound-bite, "RF energy." RF radiation is a form of energy, as is food which provides chemical energy to our bodies, as is heat which warms are bodies by converting the chemical energy into heat energy which warm our bodies, and into kinetic energy which allows our bodies to move. "RF energy" provides a positive spin suggesting a benefit instead of a hazard. The appropriate term is RF radiation, which has been declared a "possible carcinogen" by the World Health Organization (WHO).

Going with the energy concept, they make completely irrelevant analogies to light bulb energy. "For perspective, consider that 1 watt is 1/60th the power of a typical light bulb. A light bulb transmits light, not RF, but both are non-ionizing electromagnetic energy and are measured in watts." (Exponenttestimony, 11/16/10

[3] David Michaels is an epidemiologist, director of the Project on Scientific Knowledge and Public Policy, and a Professor in the Environmental & Occupational Health Department at the George Washington University. He served in the Clinton administration as Assistant Secretary of Energy for Environment, Safety, and Health. In 2006, he received the American Association of the Advancement of Science's Scientific Freedom and Responsibility Award.

p. 13). A Watt of visible light has no equivalence to a Watt of modulated RF. The only purpose of this "perspective" is to confuse and create doubt.

Q. The Exponent testimony discusses certain reviews of the scientific evidence issued by various agencies and organizations since 2010, including reports by the International Agency for Research on Cancer (IARC); the Advisory Group on Non-Ionizing Radiation (AGNIR); the California Council on Science and Technology (CCST); the European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN), the ICNIRP Standing Committee on Epidemiology; and the Swedish Council for Working Life and Social Research. Are you familiar with these organizations and agencies and their recent reports?

A. Yes, I am. I noticed that Dr. Bailey did not mention how these agencies receive their funding, who they are accountable to, or what expertise the agencies and the individuals conducting the reviews have in the science or public health risk analysis. I also noticed that Exponent did not testify much about the major scientific studies that have become available since 2010. Instead they relied on the opinions of other scientists conducting these "major reviews" without disclosing the interests, affiliations, and expertise of the scientists and the agencies, or their sources of funding.

Q. Do you have concerns about the work of these agencies and organizations and the conclusions of their reports?

A. Most of these and other agencies reviewing science for regulatory purposes have links to the industries being regulated. Attached as Exhibit C is a list of articles reporting on these industry associations and their influence on scientific reviews.

The typical conclusions of the reports cited in the Exponent testimony are stated in the negative – basically stating that there is not enough evidence yet to establish or confirm the causal[4] link between low-level RF exposure and health risks. That is to create uncertainty and doubt in favor of their industrial clients. Because their client is industry the impacts on the consumer or the public are not adequately considered. The evidence of non-thermal biological effects from radio frequency radiation is overwhelming but the scientists appointed to these agency review boards are so influenced by their industrial affiliations, consciously or not, that they use the subjective process of "weighing the evidence"[5] to disregard the hundreds of studies confirming biological effects and to give the benefit of the doubt to the industry.

Here are just a few examples of their associations with industry.

The chairman of AGNIR is Professor Anthony J Swerdlow (AJS). He is also an ICNIRP Commissioner. Professor Swerdlow's conflicts-of-interest with the cellphone industry were disclosed in an ICNIRP paper which stated:

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[4] The nature of scientific conclusions is always conditional. As the evidence of associations between an exposure and a result increases, the *probability* of cause increases. It is not the role of science to establish policy based on the evidence, it is the role of governmental agencies is to establish policy.

[5] The term "weighing the evidence" as used by industry often means counting the studies which find an effect against those not finding an effect. Because industry funds the great bulk of the studies it is not surprising when sometimes the weight falls on the side of industry. Independent scientists perform a review of the quality of each study and the source of the funding to determine where the weight of the evidence lies (Myung et al in Exhibit B). Also see additional information below.

> Funding for research by M.F and A.J.S. has been provided by a number of sources, including the European Fifth Framework Program; the International Union against Cancer, which receives funds from the Mobile Manufacturers' Forum and the GSM Association; the Mobile Telecommunications Health and Research Programme; the Swedish Research Council; AFA Insurance; and VINNOVA (Swedish Governmental Agency for Innovation Systems). VINNOVA received funds from TeliaSonera, Ericsson, and Telenor ... A.J.S. holds shares in the telecoms companies Cable and Wireless Worldwide and Cable and Wireless Communications. A.J.S.'s wife holds shares in the BT group, a global telecommunications services company.

Professor Ahlbom is an epidemiologist who has consistently denied the existence of brain tumor risks from mobile phones and more or less acted as a spokesman for industry in Europe. IARC removed him from its panel of experts evaluating the cancer risks posed by mobile phones, when it discovered his undisclosed conflict of interest. He was a director of his brother's consulting firm, Gunnar Ahlbom AB, which was established to help clients in the telecommunications industry on regulatory issues. It has been reported that Ericsson, the telecom company with networks handling 40% of all mobile phone calls made in the world, is a client of Gunnar Ahlbom AB.

Professor Ahlbom was the lead author of the 2012 report by the Swedish Council for Working Life and Social Research. Exponent cites Ahlbom's report for the following dubious conclusions.

> Extensive research for more than a decade has not detected anything new regarding interaction mechanisms between radiofrequency fields and the human body and has found no evidence for health risks below current exposure guidelines. While absolute certainty can never be achieved, nothing has appeared to suggest that the since long established interaction mechanism of heating would not suffice as basis for health protection. (Ahlbom 22 et al., 2012, p. 31).

This statement completely ignores the IARC 2B finding and other major scientific studies, and demonstrates Professor Ahlbom's clear bias in favor of the industry. The report does not even mention Ahlbom's own finding of a statistically significant 290% increase risk of acoustic neuroma on the side of the head where the cellphone was used. Ahlbom et al, Mobile Phone Use and the Risk of Acoustic Neuroma, Epidemiology, 2004 Nov;15(6):653-9.

The Swedish Council report mischaracterizes much of the scientific evidence. For instance, it states: "[R]eports of implausible amounts of use[6] were more common among cases than among controls (The Interphone study group, 2010)." Yet the Interphone study found a statistically significant risk, 118% increase risk of brain cancer (glioma) for cellphone use of 10+ years compared to use of 1.0-1.9 years, and an 82% increased risk of brain cancer for cumulative hours of use of 1,640 hour or more compared use of less than 5 hours. In essence, in spite of copious findings to the contrary and additional studies never cited, Ahlbom et al contend in their Swedish Council report that there is nothing to be concerned about.

Professor Ahlbom is also a member of the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and a contributor to the 2009 SCENIHR report (relied upon by Exponent), along with Prof. Mats-Olof

[6] The implausible amounts of use was "This exposure category includes some highly implausible reported values of mobile phone use (e.g., 12+ reported hours of use per day), which were more common in glioma cases than in controls." With 7,825 subjects in this study, that "some" subjects would report 12+ hours per day does not seem implausible. The reality is that "implausible" is the hook used by Ahlbom to

Mattsson. According to Prof. Mattson's 2010 declaration of interest he serves on an advisory board for Telia Sonera, the Swedish cellphone company. Another contributor to the report is Prof. Dr. Myrtill Simkó, whose declaration of interest disclosed that a close family member is a consultant to the Swedish cellphone company, Telia Sonera. It must be kept in mind that the reports of these organizations represent the opinions of a few scientists (some of which such as Ahlbom are authors of several of these reports) sitting on the committees issuing the reports. As stated in the SCENIHR 2009 report: "The opinions of the Scientific Committees present the views of the independent scientists who are members of the committees. They do not necessarily reflect the views of the European Commission." As we have seen, many of these scientists are not "independent," they are in-fact funded or otherwise influenced by industry.

In November, 2011, The International EMF Alliance, an organization independent of industry, representing hundreds of organizations, scientists and doctors issued a statement expressing concern about the "lack of transparency and pluralism in the evaluation of evidence by SCENIHR and other EU risk assessment committees." Attached as Exhibit D, is a copy of this statement. The statement criticizes the risk assessment reports for not providing a "fully transparent, traceable account of the process for evaluating evidence and drawing conclusions. In some cases summaries of reports do not correctly reflect the evidence from underlying chapters." The accuracy of these criticisms is readily

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discredit the whole Interphone study.

apparent when reading the SCENIHR 2009 report and the AGNIR 2012 report.

ICNIRP is the standard-setting organization that all of these other agencies rely on and defer to. The November, 2011 statement by the International EMF Alliance refers to the ICNIRP's interpretation of the scientific evidence as "highly controversial." ICNIRP is accountable to no government, public health agency, or medical body, yet it opines on the "safety" of non-ionizing radiation. Besides being non-accountable, ICNIRP is a self-perpetuating organization that selects its own Commissioners. Dr. Devra Davis in her book *Disconnect, The Truth About Cell Phone Radiation, What the Industry Is Doing to Hit It, and How to Protect Your Family,* exposes ICNIRP's association with the cellphone industry. She writes (page 48):

> The ICNIRP is not directly funded by industry, but a project with which half its members are tied provides financial backing from the Royal Adelaide Hospital of Australia. One would not think at first glance that hospital might be a conduit for passing along money. But, in fact, the cell phone industry for many years provided several hundred thousand dollars to the hospital, which passed it on to the WHO Electromagnetic Field (WHO EMF) project. Over the years, the WHO EMF project has evaluated cell phone risks and provided other advice to the ICNIRP regarding electromagnetic and cell phone radiation.

Michael Repacholi, who founded ICNRIP and founded the WHO International EMF Project, was formerly employed by the Royal Adelaide Hospital.

The Exponent witnesses also cite a report by the Biological Effects Policy Advisory Group (BEPAG). BEPAG was formed by the Institute of Engineering and Technology in the UK. In its 2012 Position Statement, BEPAG concluded '...that the *balance of scientific evidence* to date still does not indicate that harmful effects occur in humans due to low-level exposure to EMFs." (BEPAG, 2012). Again the conclusion is based on the group's *subjective* judgment "balancing" or "weighing" the positive and negative evidence. This "weight of the evidence" (WOE) process has been referred to as a "'black box' of scientific judgment." "Without an explication of how evidence is 'weighed' or 'weighted,' the claim WOE seems to be coming out of a "black box" of scientific judgment." S. Krimsky, PhD, *The Weight of Scientific Evidence in Policy and Law*, Amer. J. of Public Health, July 2005, Vol. 95.

The Institute of Engineering and Technology (IET), is a UK professional society of engineers and other technologists who by their very nature cannot be independent of the industries that employ them. The IET is similar to the Institute of Electrical and Electronic Engineers (IEEE) in the United States, which created the existing US exposure limits.

Exponent does not quote the following sentence in the BEPAG report: "Perhaps the greatest area of public concern remains the possibility of adverse effects from long-term mobile phone use." Although BEPAG makes reference to the 13-country Interphone study the results of these studies are not mentioned. The Interphone study found statistically significant risks of glioma and

meningioma: 2.18-fold for brain cancer (glioma) when cellphone use exceeded 10 years compared to use of 1.0-1.9 years, and a 1.82-fold for use of more than 1,640 cumulative hours of use compared to less than 5 hours of use. The Interphone study reported a statistically significant increased risk of 179% for acoustic neuroma for 1,640 cumulative hours of use with 5 or more years of cellphone use.

Q. What is your reaction to Exponent's criticism of the IARC 2B classification for RF exposure, in which they cite a report by the German Commission on Radiological Protection (SSK) recommending a more detailed IARC rating system for carcinogenicity with eight rather than five categories?

A. To date IARC has produced 106 Monographs examining the carcinogenicity of agents. The IARC system was developed over decades with multiple experts from many countries. The proposal would certainly serve Exponent's purpose of making the classification process overly restrictive. The worst part of the proposal is the expectation that "evidence from physical mechanisms" is required. Such a requirement is anti-science. In the history of science, it can take decades to centuries for physical mechanisms to become understood, but the lack of a physical mechanism does not negate the data. Data is gospel in science. It is reasonable to challenge the accuracy of the data, but it is irrational and anti-scientific to challenge the data on the basis that there is no known physical mechanism to fully explain the data.

In an attempt to minimize the seriousness of the World Health Organization's finding of a possible carcinogen, Exponent states that other 2B

substances include "pickled vegetables and coffee." Agents that are also included (with commonly recognizable names) are: carbon tetrachloride, chlordane, cobalt and cobalt compounds, DDT, lead, magnetic fields [from electricity], nickel metallic and alloys, styrene, vinyl acetate, diesel fuel, gasoline, and welding fumes. The point is that being classified a possible carcinogen is a serious matter. Would anyone choose to be heavily exposed to any of the agents on this abbreviated list? Most of us drink coffee, but how many of use drink 10 cups a day? While most of these are not common exposures many are both common and involuntary exposures.

Q. The Exponent witnesses cite evidence of a lack of any increased incidence of brain tumors as a basis for questioning the IARC 2B classification. What other evidence is available about incidence rates for brain cancer?

A. While there are various problems with the 3 studies Exponent cites, what is far more important is there are now data showing increased incidence rates of brain cancer in Denmark, the United States, and Australia.

The Danish Cancer Registry reported in early November 2012 a doubling of the most aggressive brain cancer, glioblastoma multiforme in the last 20 years.

Dr. Devra Davis presented a poster at the American Public Health Association in October 2012 showing a significant annual increase of brain cancer (glioma) in the United States for people younger than 50 years of age between the years 1990-2009. "From 1990-2009 for males and females <20, glioma incidence increased significantly (2.2% and 1.7% APC [Annual Percentage Change]

respectively) with similar patterns for men and women ages 20-29 (1.7 and 1.1 %), 30-39 years (3.4 and 3.0%)"

An Australian paper reported, "A significant increasing incidence in glioblastoma multiforme (GBM) was observed in the study period (annual percentage change [APC], 2.5; 95% confidence interval [CI], 0.4–4.6, n = 2275), particularly after 2006." M. Dobes, B. Shadbolt, V.G. Khurana, S. Jain, S.F. Smith, R. Smee, et al., A multicenter study of primary brain tumour incidence in Australia (2000-2008), Neuro Oncology 13 (2011) 783–790.

In a recent paper reviewing all the evidence on incidence rates, Hardell concluded "that one should be careful using incidence data to dismiss results in analytical epidemiology." Hardell, Carlberg, Hansson Mild, Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma, Pathophysiology, accepted 15 November 2012. A copy of this paper is attached as Exhibit E

Q. Are there any safety standards or guidelines governing RF devices in the United States that are designed to protect people from non-thermal effects of RF exposure?

No. Safety standards or guidelines governing RF devices do not protect people from the myriad of non-thermal (no measureable temperature change) findings of adverse health effects from RF radiation devices. The "safety" standards are based only on immediate (acute) effects from excess heat averaged over 30 minutes. Long-term (chronic) effects from heating are not considered. The

"safety" standards do not address peak-power effects. Yet during the evolution of today's standard the American National Standards Institute (ANS) stated, "It was recognized that the specific absorption rate (SAR), which provides the basis for limiting power densities, *does not contain all of the factors that could be of importance in establishing safe limits of exposure*. First, other characteristics of an incident field such as *modulation frequency* and *peak intensity* may pose a risk to health" [*emphasis* added] (ANSI, 1982, p. 14)."

There is a large body of scientific literature which has found adverse effects from non-thermal (no measurable change in temperature) exposure to electromagnetic fields (ELF and RF). The FCC guidelines also do not adequately consider the greater exposure risks for children or for particularly susceptible organs like the eyes and testes. *See* Om Gandhi, et al., Exposure Limits: The underestimation of absorbed cell phone radiation, especially in children, Electromagnetic Biology and Medicine, March 2012, Vol. 31, No. 1. A comprehensive review of low-level RF effects on reproductive processes is provided in the Bioinitiative Report, 2012, Section 18. The Introduction to Section 18 states, "This review presents evidence for ELF-EMF and RFR effects on many parameters of male sperm function; leading to questions about the genotoxicity and carcinogenicity of such exposures on fertility and reproduction in men."

Q. Do you agree with the Exponent witnesses' assertions that RF exposures from smart meters are many times less intense than from cell phones?

A. The table provided in the Exponent testimony (p 5) is based on *average* power densities. What is important is the peak-power density. As an example of why peak-power, not average power, is what matters: If a bullet is shot through your head in a thousandth of a second, the bullet's impact averaged out over a longer period, say 30 minutes, would likely suggest that little or no harm was caused. Elsewhere in their testimony, Exponent witnesses admit that "the peak power of a CMP Smart Meter is similar to a mobile phone." Exponent, p 32.

Q. The Exponent witnesses testified that: "The assessment of a health risk from any source is tied to the level of exposure, so that for any effect caused by a high level of exposure, lesser effects or no effect are anticipated at low levels of exposure." Do you agree with this assertion?

A. This is the scientific principle of dose-response. The principle does not always apply. Here, Exponent is arguing that if health risks are not identified by research on the higher RF exposure from mobile phones, then health risks are particularly unlikely with the considerably lower exposure associated with Smart Meters." First, they assume Smart Meters result is a "considerably lower exposure" than other sources, but as they have stated, the peak-power density from a smart meter is comparable to other exposures including cell phones. Second, while the principle may apply to chemical toxicology it does not necessarily apply to electromagnetic radiation (EMR) exposure. Biological effects from EMR exposures have been found to interact with the vectors of the earth's static magnetic field and EMR. There are window effects where differing effects are

found within different frequency and exposure ranges. There are threshold effects where an effect is only seen above an exposure; there are resonance effects that only occur within a small range of frequencies; and there are interactive-resonance effects where the effect is only seen with a small range of frequencies interacting with the vector of a static field (e.g., Earth's magnetic field) and the vector of a dynamic field.

Q. Are you aware of any studies demonstrating with any degree of certainty that exposure to radio frequency waves in or near the 2.4 GHz range is safe?

A. No, but many studies report adverse health effects from exposure to microwave radiation, including some in the 2.4GHz range. It is important to understand that the specific carrier frequency, 2.4 GHz in this case, is relatively unimportant. What is very important is the modulation of the carrier frequency. For example, in the EU's REFLEX studies of human cells they found that the threshold for genotoxic (damage DNA) effects on human fibroblast cells from exposure to 2nd generation (G2) cellphone modulation (GSM) was a specific absorption rate (SAR) of 0.30 W/kg (GSM Effects: Risk Evaluation of Potential Environmental Hazards From Low Frequency Electromagnetic Field Exposure Using Sensitive in vitro Methods, QLK4-CT-1999-01574 / REFLEX / Final Report, Figure 94, page 128), In contrast a similar genotoxic effect from 3rd generation cellphone modulation (UMTS) was found at a SAR=0.05 W/kg (the FCC SAR limit is 1.6W/kg). In other words, the threshold for damaged DNA in human fibroblast cells is 6 times lower from G3 modulation compared to G2 modulation. (UMTS

Effects: Schwarz et al. Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health (2008) 81:755–767). Like cell phones, smart meters radiate sharp pulses or bursts of modulated carrier frequency waves.

Q. Is there evidence of adverse biological effects associated with low-level RF at intensities in the range of 0.4 mW/cm^2 or less?

A. Yes, there are many studies reporting biological effects at very low levels of power density. Attached as Exhibit F is a partial list of human studies showing adverse effects with average levels of power density exposure below the average level expected from a smart meter.

In addition to the recommendations made in the Biointiative Report, 2012, many scientists, who are among the most qualified experts in this field, have concluded that precautions should be taken to avoid exposure to very low-level modulated RF. See the following documents attached as Exhibits G-J:

> Fragopoulou et al, Scientific panel on electromagnetic field health risks: consensus points, recommendations, and rationales. Rev Environ Health. 2010 Oct-Dec;25(4):307-17 (Ex. G, reporting evidence of adverse health effects as low as 0.0085 mW/cm^2);
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> The London Resolution (Ex. H, calling on the ICNIRP to reassess exposure guidelines and for use of precautionary measures in the use of RF devices);

The Porto Alegre Resolution (Ex. I, recommending the use of precautionary measures in the use of RF devices and stating that ICNIRP and IEEE/ICES standards "are being supported and promoted by interested parties");

and The Venice Resolution (Ex. J, recognizing the growing public health problem of electrohypersensitivity and calling for precautionary measures and the development of new standards).

There are also many highly knowledgeable public policy experts and physicians who make similar recommendations. See the following documents attached as Exhibits K - P:

2011 European Environment Agency Statement on Mobile Phones and the Potential Head cancer risk for the EMF Hearing on EMF (Ex. K, making the case that a proper and transparent consideration of the strength of the evidence, consistent with Bradford Hill's paper,[7] requires the use of precautionary actions to reduce exposures to RF);

2012 Institute for Health and the Environment, Smart Meters: Correcting the Gross Misinformation (Ex. L, calling for correction of misinformation by industry-funded studies and for precautionary measures be followed including the use of wired smart meters instead of RF emitting smart meters;

January 19, 2012 letter from the American Academny of Environmental Medicine (Ex. M, opposing the installation of wireless smart meters);

International Doctors' Appeal (Ex. N, physicians demanding use of precaution to avoid health risks of RF);

Consensus paper of the Austrian Medical Association's EMF Working Group (Ex. O, Austrian Medical Association guideline for the diagnosis and treatment of EMF-related health problems and illnesses).

Resolution 815 (2011) Resolution of Parliamentary Assembly of the Council of Europe (Ex. P, recommending "ALARA (as low as reasonably achievable) principle is applied, covering both the so-called thermal effects and the athermic or biological effects of electromagnetic emissions or radiation.")

[7] Bradford-Hill A. The environment and disease: Association or causation? *Proc R Soc Med 1965;*58:295-300.

Q. Have you reviewed the report issued by Exponent dated September 19, 2012 and titled Measurement Validation of Exposure Predictions from the Central Maine Power Smart Meter Network?

A. Yes.

Q. Have you also reviewed the Exponent testimony dated November 16, 2010 and portions of Dr. Shkolnikov's testimony at the November 9, 2012 technical conference?

A. Yes. I reviewed the November 16, 2010 and the November 9 testimony pertaining to Exponent's calculations and measurements of power density values.

Q. Do you have specific observations about or reactions to the 2010 testimony Exponent testimony?

A. Yes, there are a number of statements that require comment.

I note that Dr. Erdreich states she is a member of the ICES Standards Coordinating Committee that has developed exposure standards for EMF. Dr. Bailey also testified that he is a member of Subcommittee 4, Safety Levels with Respect to Human Exposure to Radio frequency Fields (3 kilohertz [kHz] to 3 GHz) of ICES. This would mean that both of these industry paid expert witnesses were likely involved in the creation and/or maintenance of the IEEE Std C95.1 1991 standard. This standard was adopted by the FCC in 1996 and remains the FCC exposure limit to this day. The chair of the IEEE ICES Committee

throughout the length of its creation was C-K Chou, a Motorola Executive. This serves to demonstrate how pervasive industry's influence is and how the industry influences the standard-setting process.

On page 19 Exponent puts a spin on the FCC RF standard by saying it "uses a 50-fold reduction factor below an effect level reported in research studies to arrive at an exposure limit for all members of the general public." In fact, the reduction factor for the general public is 2.5, not 50. They arrived at this 50-fold reduction factor because they asserted that hungry rats stopped looking for food at a whole body SAR of 4 W/kg. This was reduced 10-fold to 0.4 W/kg. Then considering exposure to the general public should be lower that electrical worker whose exposure is "concomitant to their employment," the general public's exposure was reduced 5-fold to a whole body SAR of 0.08 W/kg. This is how they arrived at 50-fold reduction.

In fact the hungry rats stopped looking for food at whole body SAR of 1 W/kg, and at 4 W/kg the cessation of eating when hungry was "tantamount to an irreversible effect." Thus it was not a 10 fold reduction it was a 2.5-fold reduction. The 5-fold reduction for the general public does not exist. As these exposure limits are averaged over time, the general public's averaging time is 30 minutes and the electrical workers averaging time is 6 minutes (5-fold less than the general public's time). Reducing the whole body SAR by 5 then increasing the average time by 5, results in no reduction whatsoever. It is important to note

that the ICNIRP standard recognized this nonsense. ICNIRP's averaging time is 6 minutes for both the general publics and for electrical workers.

On Page 19, Exponent suggests that the FCC standards are designed to protect children and other sensitive persons. Nothing could be further from the truth. Children have been shown in multiple studies, including industry studies (Wiart et al, Exhibit B, 46), to absorb more than double the microwave radiation when compared to adults. The existing standard does not incorporate this information.

On page 23, Exponent claims that the FCC standard is based on a review of every relevant published study and that "in its 2005 update of C95.1, IEEE listed over 1,000 published papers that it referenced in its weight-of-evidence rationale for developing the standard. In fact, IEEE uses a database that excludes many studies showing adverse health effects, and there have there have been a large number of studies since 2005 with no reconsideration of the standard. Figure 2 (page 27), shows that the FCC exposure limit is exceeded with a 10% duty cycle at less than 2 inches. Based on this data, sCMP should place a warning on all smart meters not to come closer than 2 inches from the meter.

On page 37, Exponent claims that "Smart Meters do not produce pulsed radio frequency electromagnetic fields." This is untrue. The nature of any digital signal is it is a pulsed, modulated signal.

On page 40, Exponent claims: "The WHO established the International EMF Project in 1996 to coordinate research funding and assess the scientific

evidence of possible health effects of EMF in the frequency range that includes RF (http://www.who.int/peh-emf/en/)." It was not WHO, who founded the International EMF Project it was Michael Repacholi, the founder of ICNIRP, who founded it. WHO's only role was to allow it (probably because the International EMF project received its funding from industry and WHO's funding was not required).

On page 43, Exponent claims: "Studies of a specific technology are not essential for determining possible health effects from its use." This is true to a point. However there is clear evidence that one type of modulation of carrier frequency cause adverse effects and a different modulation create adverse at a 6-fold lower level of radiation (see EU's REFLEX studies, p. 20 supra). It is essential that health effects should be tested before any new RF radiation modulation technique is introduced into our environment. As is, the largest health experiment ever performed is now underway without the informed consent of the experiment's subjects.

On page 48, Exponent acknowledges that "manufacturers of pacemakers and implantable cardioverter-defibrillators (ICD) recommend a minimum distance of 6 inches from mobile communication devices." CMP should be required to post a warning on all smart meters that a person with such medical equipment devices should keep a defined distance from the smart meter. The warning should be in sufficiently large type that it can be read from the defined distance.

Q. Do you have specific observations about or reactions to the September 19, 2012 report titled Measurement Validation of Exposure Predictions from the Central Maine Power Smart Meter Network, and Dr. Shkolnikov's testimony at the technical conference?

A. Yes, again there are a number of statements that require comment.

They state that the purpose of the study was to validate the predicted or calculated value they gave in their 2010 testimony, which was an averaged "typical" power density value of 0.000015 mW/cm2 (15 nW/cm^2) at 1 yard. Yet, they used a measuring device (Narda NBM-550) that they report as being incapable of measuring RF signals below 170 nW/cm^2 However, the NBM-550 manual states that the measurement range can be set with a minimum of 2.5 nW/cm^2 (see Narda manual, page 51; ODR 1-09 p. 59). Either Exponent chose an instrument incapable of measuring the value they sought to validate, or the instrument was capable of measuring the value to be validated, but they set the measurement range too high to measure and validate the value. They fitted the Narda NBM-550 with the EF1891 3MHz-18GHz E Field (Flat) Probe. This means that all measurement would be across a very large bandwidth, 0.003 to 18 GHz. However the frequency range of interest was a narrow range of 2.4000-2.4835 GHz (total range 0.0835 GHz and 0.46% of range this Narda meter). In effect, every measurement made was where 99.5% of the signals "seen" by the meter were not from the smart meter. If signals were outside the bandwidth of the smart meter's bandwidth were very low in relation to the signals within the bandwidth of

the smart meter, then there would be considerable underestimation of the strength of the smart meter's signals.

They brought a Selective Radiation Meter SRM-3006 that clearly had the capability of measuring 15 nW/cm^2 but they chose not to use it for that purpose. It also had the capacity to measure peak values, but they chose not to use it for that purpose either. They provided a calculated peak value in their 2010 testimony, but chose not to attempt a validation of that figure despite the fact that peak values are more relevant to non-thermal biological effects from low-level RF radiation. A spectrum analyzer is a very flexible measurement tool. It can measure peak or average. It can measure these with a defined spectrum or at specific frequencies or both.

Most importantly a spectrum analyzer has a "trigger mode" where it would capture a signal a defined signal if detected. This is of critical importance because the smart meters with their low duty cycle transmit randomly in time so without a trigger it would be nearly impossible to capture a signal when it occurs. In should be possible to trigger on all signals within the 30 minute averaging period, except that such signal would most likely not be distinguished from other ISM[8] band devices.

[8] Smart meters, Wi-Fi, cordless phones, Bluetooth devices, all share the unregulated ISM Band (Industrial, Scientific and Medical). Generally, devices operating in the ISM band have to tolerate interference generated by other ISM devices, and these devices do not require FCC licensing.

It appears that Exponent chose its equipment and designed its study to avoid capturing any smart meter packet transmission, and it appears that they succeeded.

Dr. Shkolnikov attempts to explain Exponent's lack of interest in peak values by claiming that peak values do not relate to any standards (11/9/12 Tr. p. 39). This is simply not true. There are many standards that consider peak values, including the FCC RF standards.

They emphasize that their predicted "typical" duty cycle of 0.05% represents only 43 seconds of transmission during the day. They don't mention that 43 seconds represents approximately 10,094 transmissions of RF radiation, assuming each transmissions lasts "at most 4.26 milliseconds." Report, p.6. At page 11 of the Report, they state that the worst case scenario would involve a smart meter with 4,998 descendants. With 34 packets per day per smart meter, that results in 169,966 bursts of modulated RF transmissions in one day (4998 x 34 plus 34). And this number does not include the additional "retransmit packets" that occur whenever a transmission fails. Report, p. 5. Such "failed" transmissions are likely caused by interference from Wi-Fi or other ICM band signals.

They report that: "Since the CMP Smart Meter network is dynamically configured, the communication load on any specific Smart Meter can vary from day to day." Report, p. 10. For this reason and for good public policy designed to ensure the safety of all utility customers, the only level of exposure relevant to the Commission's investigation is the worst case scenario exposure – the cumulative

effect of daily exposures from more than 169,966 bursts of modulated RF transmissions.

Q. **In your opinion, could a careful scientist familiar with the body of knowledge on the subject reliably conclude that there is no evidence of, and no risk of, non-thermal adverse health effects from exposure to RF in the range of 2.4 GHz at levels of intensity associated with smart meters?**

A. No on the contrary, careful scientists familiar with the body of knowledge on the subject would conclude that *there is* substantial evidence of risk from exposure to RF in the microwave range which includes 2.4 GHz.

The sheer numbers of people who have experienced electromagnetic hypersensitivity symptoms after exposure to smart meters should be enough for public policy makers to determine there is a serious health risk. Even if smart meter emissions did not emit enough radiation to be the sole cause of adverse health effects, the additive effect of their emissions on top of other RF emissions already in our environment can easily cause adverse health effects over time especially with the daily exposure in the home environment. To wait for further scientific proof is to engage in a very dangerous and unethical experiment on millions of human subjects with potentially huge humanitarian and economic consequences.

Dated this 31 day of January, 2013

L. Lloyd Morgan

Lloyd Morgan

Exhibit A
Curriculum Vitae

Personal Information
L. Lloyd Morgan, 2022 Francisco Street, Berkeley, CA 94709, USA
Email: Lloyd.L.Morgan@gmail.com
Phone: +510 841-4362

Education:
University of California, Berkeley, BSEE, 1964

Corporate History
1964-1966: Teacher, Morogoro Technical College, Dar es Salaam, Tanzania (calculus and electrical engineering subjects)
1966-2002: Thirty-eight years of industrial experience to the Vice Presidential level.
2002-presnt: Researcher into the biological effects from exposure to electromagnetic fields.

Memberships:
Member, Brain Tumor Epidemiology Consortium (BTEC)
Member, Bioelectromagnetics Society (BEMS)
Investigator, University of California, San Francisco of Fallon, Nevada childhood leukemia cluster
Senior Research Fellow, Environmental Health Trust

Publications
Morgan LL, Herberman RB, Philips A, Lee Davis D. Re: Mobile phone use and brain tumors in children and adolescents: a multicenter case-control study. J Natl Cancer Inst. 2012 Apr 18;104(8):635-7.

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2012: Morgan LL, Davis DL, Kundi M. Changes in Sex Ratio of Meningioma: Has Female Risk Increased for Meningioma from Exposures to Electromagnetic Radiation?
2011: Exposure Limits: The underestimation of absorbed cellphone radiation, especially in children & Hallberg O, Morgan LL. A Model to Predict Future Brain Tumor Incidence Increased Resulting from Mobile Phone Use
2010: Morgan LL, Carlberg M. Re-evaluation of the Interphone Study, Application of a Correction Factor
2009: Morgan LL. IF CELPHONE USE IS A RISK FOR BRAIN TUMORS, WHEN AND HOW MANY CELPHONE-INDUCED BRAIN TUMORS MAY OCCUR?
2008: Morgan LL. Interphone Brain Tumors Studies To Date, An Examination of Poor Study Design Resulting in an UNDER UNDER-ESTIMATION of the Risk of Brain Tumors
2005: Morgan LL. High Frequency Transients on Electrical Wiring, Blood Glucose Changes and Asthma Effects on Human Subjects.

American Academy of Environmental Medicine Presentations

2004: High Frequency Transients on Electrical Wiring, A Missing Link to Increasing Diabetes?

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EXHIBIT B

A Partial List of Studies Reporting Adverse Health Effects from Microwave Radiation

1. Argarwal et al. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. Fertil Steril. 2008 Jan;89(1):124-8. Epub 2007 May 4.

2. Auvinen, et al., Brain tumors and salivary gland cancers among cellular telephone users, Epidemiology 13 (May (3)) (2002) 356–359. [Risk of glioma (cancer) with more than 3 years of cellphone use: OR=1.7, 95% Confidence Interval 0.9 to 3.5, p=0.12, 88% confidence, and percentage increase risk of glioma per year of cellphone use: OR=1.2, 95% Confidence Interval 1.0 to 1.4, calculated p= 0.050, 95% confidence]

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16. Hardell, et al., Case–control study on radiology work, medical X-ray investigations, and use of cellular telephones as risk factors for brain tumors, MedGenMed. 2 (May 4 (2)) (2000) E2. [Risk of temporal, parietal and occipital lobe brain tumors on the same side of head as where cellphone was held: OR=2.42. 95% Confidence Interval, 0.97 to 6.05. calculated p= 0.053, 94.7% confidence]

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19. Hardell, et al., Pooled analysis of two case–control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997–2003, Int. J. Oncol. 28 (2006) 509–518.

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EXHIBIT C

Studies And Articles Regarding Industry Funding Bias And Conflicts Of Interest In Scientific Research

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2. Hardell L, Walker MJ, Walhjalt B, Friedman LS, Richter ED. *Secret ties to industry and conflicting interests in cancer research,* Am J Ind Med. 2007 Mar;50(3):227-33: http://www.ncbi.nlm.nih.gov/pubmed/17086516

3. Bhandari M, et al. *Association between industry funding and statistically significant pro-industry findings in medical and surgical randomized trials.* CMAJ, 2004 Feb 17; 170(4): 477-80: http://www.ncbi.nlm.nih.gov/pubmed/14970094

4. Mild KH, Hardell L, Kundi M, Mattsson M, *Mobile telephones and cancer: Is there really* no *evidence of* an *association?* (Review) International Journal Of Molecular Medicine 12: 67-72, 2003 www.avaate.org/IMG/pdf/Int J Mol Med 2003 12 67.pdf (regarding bias in WHO research)

5. Levis A, Minicuci N, Ricci P, Gennaro V, Garbisa S. *Mobile phones and head tumours. The descrepancies in cause-effect relationships in the epidemiological studies - How do they arise?* Environmental Health. 10:59, 2011

6. Louis Slesin, *Radiation Research and the Cult of Negative Results,* Microwave News, 2006 July; Vol. XXVI NO.4: *2-5:* http://www.microwavenews.com/docs/mwn.706.RR.pdf

7. Louis Slesin, *IARC Drops Anders Ahlbom from RF-Cancer Panel,* Microwave News, 2011 May; http://microwavenews.com/Ahlbom.html

8. The former head of the World Health Organization is Electrosensitive to EMF: http://www.mast-victims.org/resources/docs/The-Laughing-stock-and-pursuit-of-Gro Plot-issue7.pdf

9. What Corruption Looks Like: FCC Commissioner Takes Job At Comcast Months After She Voted To Approve Its Deal With NBC Universal: http://csnbbs.com/showthread.php?tid=496748

10. Leading IARC expert Anders Ahlbom linked to the Telecom Industry, by Mona Nilsson, an investigation journalist and Author, Sweden uncovered that Anders Ahlbom who was the chair of an expert group on epidemiology for the World Health Organization's IARC evaluation of the carcinogenicity of mobile phone radiation, is also the cofounder of "Gunnar Ahlbom AB" a Brussels-based lobby firm aiming to assist the telecom industry on EU regulations, public affairs and corporate communications. RF was later only classified a 2-B possible carcinogen instead of a "probable carcinogen" as many scientists had recommended.

Call for Transparent, Impartial and Pluralist Expert Assessment on health risks of non-ionizing electromagnetic fields (EMF)

Strasbourg, November 12, 2011

TO: Commissioner John DALLI, Health and Consumer Policy
CC: Commissioner Janez Potočnik, Environment
Commissioner Máire Geoghegan-Quinn, Research, Innovation and Science.

In the perspective of DG Sanco's scientific conference on Electromagnetic fields and Public Health, Nov 16-18, 2011, and IARC's classification of radiofrequency (RF) EMF as "Possibly Carcinogen" we, NGOs, MEPs and other public interest stakeholders state the following:

- We are writing to express our concerns over the narrow range of speakers and agenda items for the November 16-18 EU Commission conference on EMF, and over the lack of transparency and pluralism in the evaluation of evidence by SCENIHR and other EU risk assessment committees.

- We are concerned about the lack of transparency, impartiality and pluralism in the selection of:
  - the members of the steering committee
  - the experts represented at the conference
  - the agenda items

- There is solid evidence, from their published work for example, that most speakers, as well as most members of the steering committee which appointed them, share the same opinion on EMF health risks and support the highly controversial "ICNIRP interpretation" of the evidence on the biological effects of non-ionizing radiation. This viewpoint is only one of several scientific judgments in the well-known controversy of EMF health risks. The November group is hence not intellectually impartial according to the Commission's own standards as set out on its successful submission on this issue to the WTO Appeal Court on the beef hormones case.

- **We believe there is an effective risk that an imbalanced panel would ignore or play down the full range of plausible scientific and empirical evidence of health risks, including IARC's recent classification of RF fields as "possibly carcinogen". This would misguide the EU Commission, hinder the needed review of the Commission's recommendations, and postpone the implementation of cost-efficient preventive measures.**[1]

[1] *"Late lessons from early warnings: the precautionary principle 1896–2000"*, European Environmental Agency, 2002. Download the report here.

- We agree when the Commission, on its Communication on the Precautionary Principle (2000), recommends that "the degree of scientific uncertainty should be presented correctly", and states that the precautionary principle is applicable before a risk has been "determined with sufficient certainty."

- We fear that the reputation and credibility of DG Sanco will suffer if the present unintentional unevenness is not adjusted. We are confident that you, Commissioner Dalli, agree that pluralism is necessary for rational decision-making, and that you are as attached to transparency, impartiality and democracy as we, the Parliamentary Assembly of the Council of Europe (PACE) and WHO's International Agency for Research on Cancer (IARC) are.[2]

- This is not an isolated case. Many EU risk assessment committee reports, despite some advice on handling uncertainties from EFSA Scientific Committee, do not provide a fully transparent, traceable account of the process for evaluating evidence and drawing conclusions. In some cases summaries of reports do not correctly reflect the evidence from underlying chapters something for which IPCC has also been criticized. We have noted the recent critique of IPCC by the global scientific authority, the Inter-Academy Council, for failing to be sufficiently transparent about scientific uncertainties and for failing to provide a "traceable account" of the process of evidence evaluation and concluding judgments and their justifications.

- Such advice has since been formally endorsed by the IPCC in its revised guidance to lead authors on handling uncertainty in the next IPPC report on climate change.

We therefore ask you to:

1. **Assure that current and upcoming expert appointment processes are transparent and managed by a balanced steering committee.**
2. **Add time for a presentation of alternative scientific interpretations to the November conference.**
3. **Consider the citizens' view-points and experience as a complement to expert assessment. Consequently invite representatives from the International EMF Alliance (IEMFA) and other relevant public interest groups and assemblies to the upcoming conference and other EMF-related events.**
4. **Establish and publish a policy for risk assessment committees assuring pluralism and transparency and avoiding conflicts of interest and other bias. This guidance could be similar to that produced by IPCC.**
5. **Ensure high standard, pluralism and impartiality when selecting experts for particular reports or issues where intellectual or other bias is plausible.**
6. **Organise a conference on EMF health risks where all main scientific factions are represented, including those who conclude there are risks and a need for prevention.**

We thank your for your attention, and for considering our request.

Respectfully Yours,

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[2] IARC has stated that an IARC Monograph demands *"independence from all commercial interests and from advocates that might be perceived as advancing conceived position"*. This policy was welcomed by civil society representatives and made the participation of several controversial scientists impossible (e.g. Prof Ahlbom).

International EMF Alliance (IEMFA)

Sissel Halmøy, Folkets Strålevern, Norway, Chair
Alex Swinkels, Netherlands, Board member
Eileen O'Connor, EM Radiation Research Trust, UK, Board member
Kerstin Stenberg, Priartem, France, Board member

IEMFA represents the following organisations:

• Alliance for Irish Radiation Protection	Ireland
• American Association for Cell Phone Safety	USA
• ASANACEM/EEKNE	Spain
• Associació Oikos Ambiental	Spain
• Association for Environmental and Chronic exposure Injury	Italy
• Association for Electro Hypersensitive	Norway
• Association for Electrosensitive in Finland	Finland
• Association for the Protection of Health and the Environment	Chile
• Associazione Italiana Elettrosensibili	Italy
• AVAATE	Spain
• Bio Electromagnetic Research Initiative	United Kingdom
• Cell Tower Dangers	United States
• Center for Safer Wireless	United States
• Citizens for Safe Technology	Canada
• Citizens' Radiation Protection	Norway
• California Brain Tumor Association	United States
• Defense Association of Health and Environment	Chile
• Ecologists in Action (Ecologistas en Acción)	Spain
• EHS Association of Electrosensitives	Denmark
• EKEUKO-COVACE	Spain
• Elektrosmog-Info	Switzerland
• Elettrosmog Volturino-onlus	Italy
• Electric Sense	United States
• Electrical Pollution Solutions	United States
• Electrosensitive Society	United Kingdom
• Electromagnetic Radiation Research Foundation	South Africa
• Electromagnetic Safety Alliance	United States
• Electrohypersensitivity Foundation (Stichting EHS)	Netherlands
• Electromagnetic Fields Protection Alliance	Malaysia
• ElectromagneticHealth.org	United States
• EMFacts Consultancy	Australia
• EMF Refugee	United States
• EMR Australia	Australia
• EM Radiation Research Trust	United Kingdom
• EMR Policy Institute	United States
• Environmental Health Trust	United States
• ElectroSensitive Association (FEB)	Sweden
• Escuela sin WIFI	Spain
• Green Warriors of Norway	Norway
• Health Defense Organization	Spain
• IGEF The International Society for electromagnetic research	Germany
• Kitakamakurakeitaing	Japan
• KompetenzInitiative	Germany
• La Fundación Vivo Sano	Spain
• Limit the Radiation (Beperk de Straling)	Belgium
• Mast Action UK	United Kingdom
• Mast-Victims	United Kingdom
• Mast Sanity	United Kingdom
• NEXT-up Organisation	France
• National Platform on Radiation Risks	Netherlands
• Our Children's Future (Vore Børns Fremtid)	Denmark
• Pandora Foundation	Germany
• PRIARTéM	France
• Powerwatch	United Kingdom
• Radiation Education	Canada

Cont. IEMFA supporting organisations

- Rete Elettrosmog free Italia — Italy
- Robin des Toits — France
- StopUMTS — Netherlands
- StralingsArmVlaanderen — Belgium
- Teslabel — Belgium
- The People's Initiative Foundation — United States
- VGM Verein für Gesundheitsverträglichen Mobilfunk — Lichtenstein
- WaveBreaker (Vågbrytaren) — Sweden
- WEEP (Wireless Electrical and Electromagnetic Pollution) — Canada
- WiFi in schools — United Kingdom
- Wirelesswatchblog — United States
- WiredChild — United Kingdom

International and pan-European NGOs

- Health and Environment Alliance, HEAL, — (70 member organisations)
- Women in Europe for a Common Future, WECF — (100 member organisations)
- Pesticide Action Network-Europe, PAN-Europe — (31 member organisations)

Other Non Governmental Organisations and Coalitions

- Réseau Environnement Santé (21 associations) — France
- Bund für Umwelt und Naturschutz Deutschland e.V. (BUND)/ Friends of the Earth (480 000 members) — Germany
- The Wireless Radiation Safety Council — Canada
- The Coalition to Stop Smart Meters, — Canada
- R.I.S.K. (Rebutting Industry Science with Knowledge) — Belgium
- Swedish Radiation Protection Foundation — Sweden
- Initiativ Liewensufank — Luxembourg
- British Society for Ecological Medicine — United Kingdom
- BUND, Naturschutz in Bayern — Germany
- AKUT — Luxemburg
- Irish Doctors Environmental Association (IDEA) — Ireland
- Irish Electromagnetic Radiation Victims Network (IERVN) — Ireland
- Diagnose-Funk e.V. — Germany
- Diagnose-Funk e.V. — Switzerland
- The GalileO Project — USA
- C.H.A.S.M. (Coalition for Health / Against Smart Meters) — USA
- PACTS, People Against Cell Towers at Schools — USA
- A.P.P.L.E. Associazione Per la Prevenzione e Lotta all'Elettrosmog — Italy
- Ezpitsua, Basque Country — Spain
- Ekologistak Martxan, Basque Country — Spain
- h.e.s.e project — Germany
- Elektrosmognews — Germany
- ASQUIFYDE — Spain
- PMI - Plattform Mobilfunk-Initiativen — Austria
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- Kriton ARSENIS — S&D — Greece
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Dr. Med. Markus Kern	Germany
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Antero Kassinen, Lawyer	Finland
Mats Dämvik, Lawyer	Sweden
Johan Bonander: Clergyman, freelance journalist	Sweden
Mona Nilsson, Journalist, Environmental Economist	Sweden
Sven Leistikow, Lawyer	Germany
B. Blake Levitt, author	USA

Enclosures:

1. IEMFA's "General opinion on risk assessment".
2. « European Parliament resolution of 2 April 2009 on health concerns associated with electromagnetic fields » (2008/2211(INI). The Ries-resolution.
3. The Parliamentary Assembly of the Council of Europe's resolution on « The potential dangers of electromagnetic fields and their effect on the environment ». Resolution 1815.
4. "Health risks from mobile phone radiation – why the experts disagree", European Environment Agency, October 12, 2011. EEA statement.

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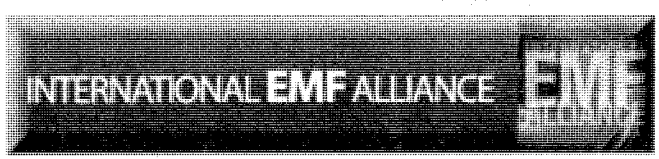

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Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma

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Abstract

The International Agency for Research on Cancer (IARC) at WHO evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24–31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists and categorised the radiofrequency electromagnetic fields from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields (RF-EMF), as Group 2B, i.e., a 'possible', human carcinogen. The decision on mobile phones was based mainly on the Hardell group of studies from Sweden and the IARC Interphone study. We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. Results for cordless phones are lacking in Interphone. The meta-analysis gave for glioma in the most exposed part of the brain, the temporal lobe, odds ratio (OR) = 1.71, 95% confidence interval (CI) = 1.04–2.81 in the ≥10 years (>10 years in the Hardell group) latency group. Ipsilateral mobile phone use ≥1640 h in total gave OR = 2.29, 95% CI = 1.56–3.37. The results for meningioma were OR = 1.25, 95% CI = 0.31–4.98 and OR = 1.35, 95% CI = 0.81–2.23, respectively. Regarding acoustic neuroma ipsilateral mobile phone use in the latency group ≥10 years gave OR = 1.81, 95% CI = 0.73–4.45. For ipsilateral cumulative use ≥1640 h OR = 2.55, 95% CI = 1.50–4.40 was obtained. Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies. Survival of patients with glioma was analysed in the Hardell group studies yielding in the >10 years latency period hazard ratio (HR) = 1.2, 95% CI = 1.002–1.5 for use of wireless phones. This increased HR was based on results for astrocytoma WHO grade IV (glioblastoma multiforme). Decreased HR was found for low-grade astrocytoma, WHO grades I–II, which might be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis. Some studies show increasing incidence of brain tumours whereas other studies do not. It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology. The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.

Keywords: Brain tumour; Glioma; Meningioma; Acoustic neuroma; Wireless phones; Incidence; Adolescent risk; CEFALO; Danish cohort

1. Introduction

On 31 May 2011 the International Agency for Research on Cancer (IARC) at WHO categorised the radiofrequency electromagnetic fields (RF-EMF) from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields, as a Group 2B, i.e., a 'possible', human carcinogen [1,2]. Nine years earlier IARC had also classified extremely low frequency (ELF) magnetic field as Group 2B carcinogen [3].

The IARC evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24–31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists representing four areas: 'animal cancer studies', 'epidemiology', 'exposure' and 'mechanistic and other relevant data'. The expert groups initially prepared a written draft prior to the IARC meeting. Further work was done in the expert groups and a final agreement, sentence by sentence, was obtained during plenary sessions with all experts participating.

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The IARC decision on mobile phones was based mainly on two sets of case-control human studies; the Hardell group of studies from Sweden and the IARC Interphone study. Both provided complementary and supportive results on positive associations between two types of brain tumours; glioma and acoustic neuroma, and exposure to RF-EMF from wireless phones.

The final IARC decision was confirmed by voting of 29 scientists (one not present). A large majority of participants voted to classify RF-EMF radiation as 'possibly carcinogenic' to humans, Group 2B. The decision was also based on occupational studies.

In this paper an up-to-date review of the evidence of an association between use of wireless phones and brain tumours is presented. The Nordic countries were among the first countries in the world to widely adopt wireless telecommunications technology. Analogue phones (NMT; Nordic Mobile Telephone System) were introduced in the early 1980s using both 450 and 900 Megahertz (MHz) frequencies. NMT 450 was used in Sweden from 1981 but closed down on 31 December 2007, NMT 900 operated during 1986–2000.

The digital system (GSM; Global System for Mobile Communication) using dual band, 900 and 1800 MHz, started to operate in 1991 and dominates now the market. The third generation of mobile phones, 3G or UMTS (Universal Mobile Telecommunication System), using 1900/2100 MHz RF fields has been introduced worldwide in recent years, in Sweden in 2003. Currently the fourth generation, 4G (Terrestrial 3G), operating at 800/2600 MHz and Trunked Radio Communication (TETRA 380–400 MHz) are being established in Sweden and elsewhere. Nowadays mobile phones are used more than landline phones in Sweden (http://www.pts.se/upload/Rapporter/Tele/2011/sv-telemarknad-halvar-2011-pts-er-2011-21.pdf). Worldwide, an estimate of 5.9 billion mobile phone subscriptions was reported at the end of 2011 by the International Telecommunication Union (ITU; http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf). Many users are children and adolescents, which is of special concern regarding potential health effects.

Desktop cordless phones (DECT) have been used in Sweden since 1988, first using analogue 800–900 MHz RF fields, but since early 1990s using a digital 1900 MHz system. The cordless phones are becoming more common than traditional landlines. Also these phones emit RF-EMF radiation similar to that of mobile phones. Thus, it is also necessary to consider the usage of cordless phones along with mobile phones, when human health risks are evaluated. It should be noted that the usual cordless base stations emit RF-EMF continuously. They are often installed in offices close to the person using a cordless phone handset or in homes even in bedrooms next to the head of a sleeping person.

The real increase in use and exposure to electromagnetic fields from wireless phones (mobile phones and cordless phones) in most countries has occurred since the end of the 1990s. When used they emit RF-EMFs. The GSM phones and to a lesser extent the cordless phones emit also ELF-EMF from the battery when used [4,5]. The brain is the main target organ during use of the handheld phone [6]. Thus, fear of an increased risk for brain tumours has dominated the debate during the last one or two decades. While RF-EMFs do not have sufficient energy to break chemical bonds like ionising radiation, at least not directly, they can nevertheless have harmful effects on biological tissues. Plausible biological mechanisms for these effects include impairment of DNA repair mechanisms and epigenetic changes to DNA.

Primary brain tumours (central nervous system; CNS) constitute of a heterogeneous group of neoplasms divided into two major groups; malignant and benign. They are of different histological types depending on tissue of origin with different growth patterns, molecular markers, anatomical localisations, and age and gender distributions. The clinical appearance, treatment and prognosis are quite different depending on tumour type.

Ionising radiation is an established risk factor for primary brain tumours [7], but there are no well-established environmental causes. Higher socio-economic status tends to be related to higher incidence and some rare inherited cancer syndromes account for a small fraction of tumours [7]. Familial aggregation of glioma has been reported. In a large study 77% more glioma cases than expected were reported among family members [8].

The purpose of this article is to give a comprehensive review of the association between use of mobile and cordless phones and brain tumours, primarily based on the results of the major publications in this field. We include the Hardell group papers and the WHO Interphone study [9–11]. Also some additional analyses of the risk for brain tumours based on these results are given. Some early studies not part of these two major study groups are also included. More discussion of the results and responses, agreements and disagreements of the findings for the Hardell group and Interphone studies can be found elsewhere [12]. In addition, this review includes studies published after the IARC evaluation in May 2011.

2. Materials and methods

The PubMed database (www.ncbi.nlm.nih.gov) was used for an up-dated search of published studies in this area using mobile/cellular/cordless telephone and brain tumour/neoplasm/acoustic neuroma/meningioma/glioma as searching terms. Personal knowledge of published studies was also used in order to get as comprehensive a review as possible. All of the authors have long experience in this research area and have published the pioneer studies indicating an association between use of wireless phones and certain types of brain tumours. They represent different supportive areas of competence such as oncology, cancer epidemiology, statistics and physics.

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Table 1
Summary of studies on the use of mobile phones and brain tumour risk.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15,16] Sweden	1994–1996; Case-control	20–80 years	Brain tumours ($n=209$)	78	OR 0.98 (0.69–1.41)	Analogue and digital mobile phone use
				34	OR 1.07 (0.64–1.80)	*Ipsilateral* mobile phone use
				16	OR 1.20 (0.56–2.59)	>10 year latency, analogue mobile phone use
Muscat et al. [17] USA	1994–1998; Case-control	18–80 years	Brain tumours ($n=469$)	66	OR 0.8 (0.6–1.2)	Mean duration of mobile phone use 2.8 years
			Neuorepithelioma ($n=35$)	14	OR 2.1 (0.9–4.7)	

2.1. Statistical methods

All analyses in the Hardell group studies were done using StataSE 10.1 (Stata/SE 10.1 for Windows; StataCorp., College Station TX). Odds ratios (OR) and 95% confidence intervals (CI) were calculated using unconditional logistic regression analysis. Further details can be found in the publications.

Meta-analyses were performed on use of mobile phones in the Hardell group [13,14] and Interphone group [9,10] studies. No duplicate data from different articles published by the same group of authors were included. Model was chosen based on test for heterogeneity in the overall ($\geq$10 years and $\geq$1640 h) groups. In the analysis of survival of patients with glioma, Cox proportional hazards model was used to calculate hazard ratios (HR) and corresponding 95% confidence intervals. Follow-up time was counted from the date of diagnosis to the date of death or until May 30, 2012 for living cases.

3. Results

3.1. Brain tumours overall

The first study by Hardell et al. [15,16] included cases and controls during 1994–1996 in parts of Sweden and was the first published study on this issue. Only living cases diagnosed during 1994–1996 were included. Two controls were selected to each case from the Population Registry. In total 209 (90%) of the cases and 425 (91%) of the controls that met the inclusion criteria answered the mailed questionnaire. Overall no association between mobile phone use and brain tumours was found. A slightly increased, but not statistically significant, risk was found for analogue phone (NMT) use and for a latency period greater than 10 years, OR = 1.20, 95% CI = 0.56–2.59, Table 1.

Exposure to the radiation from the phones is generally higher in the temporal lobe, the part of the brain that is near to the ear [6]. For tumours located in the temporal, occipital or temporoparietal lobe areas of the brain an increased risk was found for ipsilateral exposure, that is the telephone was mostly used on the same side of the head as the tumour appeared, yielding OR = 2.42, 95% CI = 0.97–6.05 [16]. This was the first study in the world that indicated an association between use of mobile phones and an increased risk for brain tumours. However, all results were based on low numbers of exposed subjects and different histopathological types of brain tumours so no firm conclusions could be drawn. Furthermore, this first study did not include use of cordless phones.

Muscat et al. [17] studied patients with malignant brain tumours from five different hospitals in USA, Table 1. Controls were hospital patients. Data from 469 (82%) cases and 422 (90%) controls were available. Overall no association was found, OR for handheld cellular phones was 0.8, 95% CI = 0.6–1.2, but the mean duration of use was short, only 2.8 years for cases and 2.7 years for controls. For neuroepithelioma OR = 2.1, 95% CI = 0.9–4.7, was reported. The study was inconclusive since no data were available on long-term users ($\geq$10 years latency period). Some support of an association was obtained since of 41 evaluable tumours, 26 occurred at the side of the head mostly used during calls and 15 on the contralateral side.

3.2. Glioma

Glioma is the most common malignant brain tumour and represents about 60% of all central nervous system tumours. The most common glioma subtype is astrocytoma. Astrocytic tumours are divided in two groups depending on the malignant potential; low-grade (WHO grades I–II) and high-grade (WHO grades III–IV). Low-grade astrocytoma has a relatively favourable prognosis, whereas survival is shorter for patients with high-grade glioma. Glioblastoma multiforme (WHO grade IV) accounts for 60–75% of all astrocytoma. The peak incidence is between 45 and 75 years of age with median survival less than one year [18].

In the study by Hardell et al. [15] analysis of the cases with astrocytoma produced OR = 1.09, 95% CI = 0.64–1.84 ($n=36$ cases), Table 2. OR increased further for ipsilateral exposure for right sided tumours, OR = 1.30, 95% CI = 0.54–3.13 ($n=13$ cases), whereas no association was

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Table 2
Summary of studies on the use of wireless phones and glioma risk.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15] Sweden	1994–1996; Case-control	20–80 years	Astrocytoma WHO grade I–IV ($n = 94$)	36	OR 1.09 (0.64–1.84)	Analogue and digital mobile phone use
				13	OR 1.30 (0.54–3.13)	*Ipsilateral* mobile phone use, *right* sided tumours
				3	OR 0.35 (0.07–1.81)	*Ipsilateral* mobile phone use, *left* sided tumours
Inskip et al. [19] USA	1994–1998; Case-control	≥18 years	Glioma ($n = 489$)	11	OR 0.6 (0.3–1.4)	≥5 years of mobile phone use
Auvinen et al. [20] Finland	1996; Case-control, register based	20–69 years	Glioma ($n = 198$)	Not given	OR 1.5 (1.0–2.4)	Analogue and digital mobile phone "ever" use
				25	OR 2.1 (1.3–3.4)	Analogue mobile phone "ever" used
				11	OR 2.4 (1.2–5.1)	Analogue mobile phone use, 1–2 years
				11	OR 2.0 (1.0–4.1)	Analogue mobile phone use, >2 years
Hardell et al. [26–28] Carlberg, Hardell [29] Sweden	1997–2003; Case-control	20–80 years	Glioma ($n = 1148$)	123	OR 2.5 (1.8–3.3)	>10 year latency, mobile phone
				57	OR 2.9 (1.8–4.7)	>10 year latency, mobile phone, *ipsilateral*, only living
				50	OR 2.6 (1.7–4.1)	>10 year latency, *mobile phone only*
				45	OR 1.7 (1.1–2.6)	>10 year latency, cordless phone
				20	OR 3.8 (1.8–8.1)	>10 year latency, cordless phone, *ipsilateral*, only living
				9	OR 1.2 (0.5–2.9)	>10 year latency, *cordless phone only*; >5–10 year latency OR 1.9 (1.3–2.9; $n = 55$)
				150	OR 2.1 (1.6–2.8)	>10 year latency, wireless phone (mobile and cordless phone)
			Astrocytoma, high grade ($n = 820$)	102	OR 3.0 (2.1–4.2)	>10 year latency, mobile phone
				47	OR 3.9 (2.3–6.6)	>10 year latency, mobile phone, ipsilateral, only living
				37	OR 2.8 (1.7–4.6)	>10 year latency, *mobile phone only*
				36	OR 2.0 (1.2–3.2)	>10 year latency, cordless phone
				15	OR 5.5 (2.3–13)	>10 year latency, cordless phone, ipsilateral, only living
				6	OR 0.9 (0.3–2.6)	>10 year latency, *cordless phone only*; >5–10 year latency OR 2.4 (1.6–3,7; $n = 44$)
				121	OR 2.5 (1.8–3.4)	>10 year latency, wireless phone (mobile and cordless phone)
Interphone Study Group [9] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Glioma ($n = 2708$)	1666	OR 0.81 (0.70–0.94)	Regular use of mobile phone in the past ≥1 year

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Table 2 (*Continued*)

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
				210	OR 1.40 (1.03–1.89)	Cumulative hours mobile phone ≥1640 h
				78	OR 1.87 (1.09–3.22)	Cumulative hours mobile phone ≥1640 h, tumours in *temporal lobe*
				100	OR 1.96 (1.22–3.16)	Cumulative hours mobile phone ≥1640 h, *ipsilateral* mobile phone use
Interphone Study Group [9] Appendix 2	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Glioma ($n = 1211$)	460	OR 1.68 (1.16–2.41)	Restricted to *ever regular use* time since start 2–4 years; 1–1.9 years as reference entity
				468	OR 1.54 (1.06–2.22)	Restricted to *ever regular use* time since start 5–9 years; 1–1.9 years as reference entity
				190	OR 2.18 (1.43–3.31)	Restricted to *ever regular use* time since start 10+ years; 1–1.9 years as reference entity
				160	OR 1.82 (1.15–2.89)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity

seen for astrocytoma in the left hemisphere and ipsilateral exposure, OR = 0.35, 95% CI = 0.07–1.81 ($n = 3$ cases).

The study by Inskip et al. [19] from USA had few long-term users of mobile phones. Only 11 cases with glioma, 6 with meningioma and 5 with acoustic neuroma had ≥5 years regular use. No subject had ≥10 years use. Of the hospital-based cases 92% participated. The study comprised 489 cases with glioma, 197 with meningioma and 96 with acoustic neuroma, and 799 (86%) hospital-based controls. Proxy interviews were necessary for 16% of the patients with glioma, 8% of the patients with meningioma, 3% of the patients with acoustic neuroma, and 3% of the controls. Overall no statistically significant associations were found, Table 2. Regarding different types of glioma OR = 1.8, 95% CI = 0.7–5.1 was found for anaplastic astrocytoma (WHO grade III). Regarding hospital-based interviews and use of proxy interviews, see discussion below in relation to the Interphone study.

A register based case-control study on brain and salivary gland tumours was performed in Finland [20]. All cases aged 20–69 years diagnosed in 1996 were included; 398 brain tumour cases and 34 salivary gland tumour cases. The duration of mobile phone use was short, for analogue users 2–3 years and for digital users less than one year. No association was found for salivary gland tumours. For glioma OR = 2.1, 95% CI = 1.3–3.4 was calculated for use of analogue phones, but no association was found for digital mobile phones, Table 2. When duration of use of analogue phones was used as a continuous variable an increased risk was found for glioma with OR = 1.2, 95% CI = 1.1–1.5 per year of use.

The Hardell group in Sweden studied the association between use of mobile and cordless phones and brain tumours diagnosed during 1997–2003. First, cases diagnosed during 1 January 1997 to 30 June 2000 were included. These results were published separately [21,22]. This was followed by the next study period, 1 July 2000 to 31 December 2003 [23,24]. The methods were the same including the same inclusion criteria and an identical questionnaire in both studies; see the publications for further details.

Both men and women aged 20–80 years at the time of diagnosis were included and all were alive at the time of inclusion in the study. They were reported from cancer registries with a brain tumour verified by histopathology. The Swedish Population Registry was used for identification of matched controls. The study included use of wireless phones (mobile and cordless phones), as well as asking questions on e.g., occupational exposures. Use of wireless phones was carefully assessed by a self-administered questionnaire supplemented over the phone. The ear that had mostly been used during calls with mobile phone and/or cordless phone was assessed by separate questions; >50% of the time for one side, or equally for both sides. This information was checked during the supplementary phone calls and finally also by a separate letter with good agreement between these three methods.

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Tumour localisation for the cases was defined by using medical records including computer tomography (CT) and/or magnetic resonance imaging (MRI). The matched control was assigned the same side as the tumour of the respective case. Use of the wireless phone was defined as ipsilateral (≥50% of the time), or contralateral (<50% of the time) in relation to tumour side. Further details can be found in the publications.

In a review commissioned by the former Swedish Radiation Protection Agency (now called the Swedish Radiation Safety Authority) it was suggested that the exclusion of deceased cases was a source of bias in our studies [25]. As a response to that critique we performed a study on the cases with a malignant brain tumour that had died before inclusion in the case-control studies 1997–2003. These cases represented patients with a poor prognosis, mostly with astrocytoma WHO grade IV (glioblastoma multiforme). Controls were selected from the Death Registry in Sweden.

The study encompassed 464 cases and 464 controls that had died from a malignant disease and 463 controls with other causes of death. Exposure was assessed by a questionnaire sent to the next of kin to each deceased case and control. The questionnaire was similar as in previous studies.

This investigation confirmed the previous results of an association between mobile phones and malignant brain tumours [26].

The Hardell group has previously published pooled analysis of malignant brain tumours diagnosed during the period 1997–2003 [27]. These results were updated including also results for deceased cases with malignant brain tumours [28,29]. The results on use of wireless phones were based on 1251 cases with malignant brain tumour (response rate 85%) and 2438 controls (response rate 84%).

Most cases had glioma ($n = 1148$) so we present in the following results for that type of tumour. Latency was divided in three categories, >1–5 years, >5–10 years, and >10 years from first use of a wireless phone until diagnosis of glioma. Both use of mobile and cordless phone gave an increased risk overall, highest in the latency group >10 years, increasing further for ipsilateral use yielding for mobile phone OR = 2.9, 95% CI = 1.8–4.7 and for cordless phone OR = 3.8, 95% CI = 1.8–8.1, Table 2. Highest ORs were found in the >10 year latency group for total wireless phone use as well, OR = 2.1, 95% CI = 1.6–2.8 or a doubling of glioma risk.

OR increased statistically significant for glioma for cumulative use of wireless phones per 100 h; OR = 1.014, 95% CI = 1.008–1.019, and per year of latency; OR = 1.056, 95% CI = 1.037–1.075 [29]. Separate calculations of mobile phone and cordless phone use yielded similar results with statistically significant increasing risks.

It is common for a person to use both a mobile and a cordless phone. For only use of mobile phone OR increased for glioma with time since first use yielding for >10 years latency OR = 2.6, 95% CI = 1.7–4.1. For only cordless phone use highest risk was obtained in the >5–10 years latency time; OR = 1.9, 95% CI = 1.3–2.9. However, the calculations in the longest latency period were based on few subjects regarding cordless phone.

In Table 2 results are presented for high-grade astrocytoma ($n = 820$). The results are similar as for the whole glioma group. Low-grade glioma is less common and the results in this study were based on 132 cases. Ipsilateral use of mobile phone yielded in total OR = 1.8, 95% CI = 1.02–3.1 ($n = 39$ cases) and cordless phone OR = 1.7, 95% CI = 0.98–3.1 ($n = 34$ cases, data not in Table). Further results and discussion may be found elsewhere [29].

The Interphone study was conducted at 16 research centres in 13 countries during varying time periods between 2000 and 2004. It was an international collaboration on brain tumour risk and mobile phone use conducted under the guidance of IARC. The investigation was initiated by recommendations from several expert groups including one of the authors, Kjell Hansson Mild as a member of the EU group, to study possible health effects of exposure to RF-EMF [30,31]. It should be noted that there was no overlap of cases or controls between the Hardell group studies and the Swedish part of Interphone performed by another research group.

Some of the separate country analyses of the Interphone study produced contradictory results, as we have discussed elsewhere [13,32]. An increased risk for brain tumour was found in some studies and decreased risk in other studies. After several years of delay the overall Interphone results were finally published in May 2010 [9].

The study included 4301 glioma cases and the results were based on 2708 participating cases (response rate 64%, range by centre 36–92%). In total 14,354 potential controls were identified and interviews were completed with 7658 (53%, range 42–74%). The low participation rates in some centres may have created selection bias, see Hardell et al. [32].

Regular use of mobile phone in the past ≥1 year gave for glioma OR = 0.81, 95% CI = 0.70–0.94, Table 2. Subgroup analyses showed statistically significant increased risk in the highest exposure group, i.e., those with cumulative mobile phone use ≥1640 h, which corresponds to about half an hour of use per day for ten years, OR = 1.40, 95% CI = 1.03–1.89. The risk increased further for glioma in the temporal lobe yielding OR = 1.87, 95% CI = 1.09–3.22. In the same exposure category, cumulative use ≥1640 h and ipsilateral exposure produced OR = 1.96, 95% CI = 1.22–3.16 in total (no data given for temporal lobe).

In Appendix 2, available on the web [9] analysis was restricted to ever-regular users of mobile phones in the Interphone study. Cumulative call time ≥1640 h gave OR = 1.82, 95% CI = 1.15–2.89 compared with use <5 h. Time since start of regular use (latency) ≥10 years produced OR = 2.18, 95% CI = 1.43–3.31; reference entity 1–1.9 years.

The Interphone study group concluded: "*However, biases and errors limit the strength of the conclusions we can draw from these analyses and prevent a causal interpretation.*" In an editorial accompanying the Interphone results the main conclusion of the Interphone results was described as "*both elegant and oracular. . .(which) tolerates diametrically*

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opposite readings" [33]. They also pointed out several methodological reasons why the Interphone results were likely to have underestimated the risks, such as the short latency period since first exposures became widespread; less than 10% of the Interphone cases had more than 10 years exposure. "*None of the today's established carcinogens, including tobacco, could have been firmly identified as increasing risk in the first 10 years or so since first exposure*".

As has pointed our elsewhere [32] there were differences between the Hardell group studies and Interphone. Regarding age group the Hardell group studies included subjects aged 20–80 years, versus 30–59 years in Interphone. Furthermore use of cordless phones was not properly assessed, analysed or reported in Interphone. These differences have been discussed in detail by Hardell et al. [14]. Thus, it could be shown that restricting the age group to 30–59 years and considering subjects that used a cordless phone as unexposed in the Hardell group studies reduced the OR and produced results quite similar to Interphone, Table 3; see also Table 11 as discussed below. Latency time >10 years for glioma in the temporal lobe yielded OR = 1.40, 95% CI = 0.70–2.81 in the Hardell group studies and OR = 1.36, 95% CI = 0.88–2.11 in Interphone (latency ≥10 years). Unfortunately the Interphone study did not give results for glioma in the temporal lobe in the analyses in Appendix 2. Thus, excluding exposure to RF-EMFs from cordless phones as in the Interphone study, as well as excluding the younger and older subjects biased the ORs towards unity, which likely dilutes the ability to see health risks.

Most mobile phone users have not been using one single telephone. It is likely that they have changed their handset several times if they have been using a mobile phone for more than a few years. Many users have also been using different phone systems, such as analogue and digital, and many of them have also been using a cordless phone at home or at work. It is not clear how to combine the use of different phones with different power outputs, systems, frequencies and anatomical specific absorption rate (SAR) distributions into one exposure and dose measure. The difficulties lie in the fact that there is no generally accepted mechanism(s) between the electromagnetic fields emitted from the phone and the biological organism. This includes a mechanism by which RF-EMF exposure produces changes in DNA. The energy level associated with exposure is too low to cause direct DNA strand breaks and DNA cross links. However, DNA damages can be caused by cellular biochemical activities such as free radicals. Several studies indicate that RF-EMFs increase free radical activity in cells, as reviewed by Phillips et al. [34]. This process is probably mediated via the Fenton reaction. It should also be noted that possible biological effects might not have linear dose–response as indicated in some studies [35] and that the effects are depending on the carrier frequencies [36].

The different types of phones have different output power. We applied different weighting factors according to the mean output power of the phones using for analogue phones (NMT) = 1, GSM = 0.1 and cordless phones = 0.01. The cumulative time for use of the different phone types was multiplied with the respective weighting factor added into one score. The median score among the controls was used as the cut-off in the dose–response calculations. We applied this method for the study period 1 January 1997 to 30 June 2000 [21,22]. Somewhat higher ORs were obtained using the weighting factor, especially with a >10-year latency period, compared with calculations based on cumulative use only, but overall the results were similar [37]. This was explained by the fact that most subjects had used an analogue mobile phone with the weighting factor = 1, thus the weighting factor had little impact on the results.

A further issue is that there is a difference in the output power level from mobile phones between urban and rural areas. This is caused by adaptive power control (APC) in the cellular telephone and is regulated by the distance between base stations. Thus, in areas with a long distance between base stations, usually rural areas, the output power level is higher than in more densely populated areas; that is, urban areas, with a shorter distance between base stations. To further explore these circumstances we used the Swedish population register that contains information on present municipality for all residents. The municipalities are classified by Statistics Sweden into so called homogeneity regions, six categories depending on the population density, and the number of inhabitants in the nearest vicinity of the main city in that municipality. Thus, we used these official statistics for grouping of the subjects in urban or rural areas for the study period 1 January 1997 to 30 June 2000. For use of digital mobile phones (GSM) we found a clear effect of urban versus rural areas [38]. Living in rural areas yielded OR = 1.4, 95% CI = 0.98–2.0, increasing to 3.2, 95% CI = 1.2–8.4 with >5 year latency time for digital phones. The corresponding ORs for living in urban areas were 0.9, 95% CI = 0.8–1.2 and 0.9, 95% CI = 0.6–1.4, respectively. This effect was most obvious for malignant brain tumours.

Estimated RF-EMF dose from mobile phone use in the tumour area was associated with an increased risk of glioma in parts of the Interphone study [11]. OR increased with increasing total cumulative dose of specific energy (J/kg) absorbed at the estimated tumour centre for more than 7 years before diagnosis giving OR = 1.91, 95% CI = 1.05–3.47 (p trend = 0.01) in the highest quintile of exposure. A similar study based on less sound methods was later published by another part of the Interphone study group [39]. The results seemed to contradict the findings of Cardis et al. [11]. However, a different, less clear method was used. Only 42 cases had used mobile phone for more than 10 years and no analysis was made of the most exposed group with longest duration of use. Thus, this study is much less informative and less sophisticated than the one by Cardis et al. [11]. It should have been of great value to apply the method by Cardis et al. for the whole Interphone study.

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Table 3
Comparison between Hardell group and Interphone using the same age group 30–59 years and excluding use of cordless phones.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [14]	1997–2003; Case-control	30–59 years	Glioma ($n=490$)	56	OR 1.79 (1.19–2.70)	>10 year latency, cordless phone among unexposed, age 30–59 years
				29	OR 1.75 (1.02–3.00)	Cumulative use ≥1640 h, cordless phone among unexposed, age 30–59 years
				20	OR 2.18 (1.09–4.35)	Cumulative use ≥1640 h, cordless phone among unexposed, age 30–59 years, *ipsilateral*
				8	OR 1.48 (0.57–3.87)	Cumulative use ≥1640 h, cordless phone among unexposed, age 30–59 years, *contralateral*
Interphone Study Group [9] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Glioma ($n=2708$)	252	OR 0.98 (0.76–1.26)	Regular use of mobile phone in the past ≥1 year, latency ≥10 years
				210	OR 1.40 (1.03–1.89)	Cumulative hours mobile phone ≥1640 h
				100	OR 1.96 (1.22–3.16)	Cumulative hours mobile phone ≥1640 h, *ipsilateral*
				39	OR 1.25 (0.64–2.42)	Cumulative hours mobile phone ≥1640 h, *contralateral*
				160	OR 1.82 (1.15–2.89)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity, Appendix 2. Results for ipsilateral and contralateral use not reported.

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Table 4
Use of mobile phones and glioma risk, meta-analysis of Hardell et al. [14] and Interphone [9]. Numbers of exposed cases (Ca) and controls (Co) are given.

	Hardell et al.		Interphone		Meta-analysis	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Latency ≥10 years						
-all	88/99	2.26 (1.60–3.19)	252/232	0.98 (0.76–1.26)	340/331	1.48 (0.65–3.35)
-ipsilateral	57/45	2.84 (1.82–4.44)	108/82	1.21 (0.82–1.80)	165/127	1.84 (0.80–4.25)
-contralateral	29/29	2.18 (1.24–3.85)	49/56	0.70 (0.42–1.15)	78/85	1.23 (0.40–3.73)
-temporal lobe	28/99	2.26 (1.32–3.86)	94/69	1.36 (0.88–2.11)	122/168	1.71 (1.04–2.81)
Cumulative use ≥1640 h						
-all	42/43	2.31 (1.44–3.70)	210/154	1.40 (1.03–1.89)	252/197	1.74 (1.07–2.83)
-ipsilateral	29/21	2.94 (1.60–5.41)	100/62	1.96 (1.22–3.16)	129/83	2.29 (1.56–3.37)
-contralateral	12/12	2.10 (0.90–4.90)	39/31	1.25 (0.64–2.42)	51/43	1.52 (0.90–2.57)
-temporal lobe	14/43	2.44 (1.21–4.95)	78/47	1.87 (1.09–3.22)	92/90	2.06 (1.34–3.17)

Random-effects model used for all meta-analyses, based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups.

3.3. Meta-analysis glioma

We performed a meta-analysis of glioma on use of mobile phones based on Hardell et al. [14] and Interphone Study Group [9]. Random-effects model was used based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups. The analysis was based on published results in Interphone since we do not have access to their database. Our results were recalculated to these groups of exposure. Thus, results can be found in Table 4 for latency ≥10 years, (>10 years in Hardell et al.), and cumulative use of mobile phone ≥1640 h. The meta-analysis yielded for mobile phone use OR = 1.71, 95% CI = 1.04–2.81 for glioma in the temporal lobe in the ≥10 years latency group. Ipsilateral mobile phone use ≥1640 h in total gave the highest risk, OR = 2.29, 95% CI = 1.56–3.37. Certainly the meta-analysis strengthens a causal association between use of mobile phones and glioma.

3.4. Meningioma

Meningioma is the most common benign brain tumour. It develops from the pia and arachnoid that covers the central nervous system. Meningioma is an encapsulated and well-demarked tumour. It is rarely malignant. More women than men develop meningioma.

In the first study by Hardell et al. [15] only 46 cases had meningioma. No increased risk was found overall; OR = 1.05, 95% CI = 0.49–2.27, Table 5. Only 16 cases had used a mobile phone. There was no pattern of increased risk for ipsilateral use, although the results were based on low numbers.

The US study by Inskip et al. [19] included 197 cases with meningioma. Regular mobile phone use produced OR = 0.8, 95% CI = 0.4–1.3, Table 5. The risk did not increase with average daily use, cumulative use, or duration of regular use. However, results for duration of regular use ≥5 years was based on only 6 exposed cases.

The Finnish register based case-control study on brain tumours by Auvinen et al. [20] included 129 cases with meningioma. Ever use of mobile phone gave OR = 1.1, 95% CI = 0.5–2.4, analogue phone use OR = 1.5, 95% CI = 0.6–3.5, Table 5. As discussed above the study was limited by short latency and exposure based on subscription information.

The Hardell group made a pooled analysis of benign brain tumours from the two case-control studies 1997–2003 as discussed above [40,41]. Regarding meningioma use of mobile phone gave OR = 1.1, 95% CI = 0.9–1.3, and cordless phone OR = 1.1, 95% CI = 0.9–1.4, Table 5. Using >10 year latency period OR increased; for mobile phone to OR = 1.5, 95% CI = 0.98–2.4, and for cordless phone to OR = 1.8, 95% CI = 1.01–3.2. Ipsilateral mobile phone use in the >10 years latency group yielded OR = 1.6, 95% CI = 0.9–2.9, and cordless phone OR = 3.0, 95% CI = 1.3–7.2. These results were based on rather low numbers of exposed cases, however.

In the Interphone study [9] a statistically significant decreased risk was found for meningioma for regular use of mobile phone, OR = 0.79, 95% CI = 0.68–0.91, Table 5. The risk increased somewhat with cumulative use ≥1640 h and ipsilateral mobile phone use to OR = 1.45, 95% CI = 0.80–2.61. The overall pattern of no association did not change if analysis was restricted to tumours in the temporal lobe or only to the group of ever-regular use.

3.5. Meta-analysis meningioma

Similarly as for glioma we performed meta-analysis of meningioma for use of mobile phone on the Hardell group and Interphone results, Table 6. Random-effects model was used in the ≥10 years group based on test for heterogeneity in the overall group. For analyses of ≥1640 h no heterogeneity was found in the heterogeneity test; random- and fixed effects models produced identical results. In summary no statistically significant decreased or increased risks were found. These results support the conclusion that up to latency ≥10 years or cumulative use ≥1640 h there is not a consistent pattern of an association between use of mobile phones and meningioma.

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Table 5
Summary of studies on the use of wireless phones and meningioma risk.

Study	Years; study type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15] Sweden	1994–1996; Case-control	20–80 years	Meningioma ($n=46$)	16	OR 1.05 (0.49–2.27)	Analogue and digital mobile phone use
Inskip et al. [19] USA	1994–1998; Case-control	≥18 years	Meningioma ($n=197$)	32	OR 0.8 (0.4–1.3)	Regular use
				6	OR 0.9 (0.3–2.7)	≥5 years of mobile phone use
Auvinen et al. [20] Finland	1996; Case-control, register based	20–69 years	Meningioma ($n=129$)	Not given	OR 1.1 (0.5–2.4)	Analogue and digital mobile phone "ever" use
				8	OR 1.5 (0.6–3.5)	Analogue mobile phone "ever" used
				3	OR 1.6 (0.4–6.1)	Analogue mobile phone use, 1–2 years
				2	OR 1.0 (0.2–4.4)	Analogue mobile phone use, >2 years
Hardell et al. [40], Hardell, Carlberg [41] Sweden	1997–2003; Case-control	20–80 years	Meningioma ($n=916$)	347	OR 1.1 (0.9–1.3)	>1 year latency, mobile phone use
				38	OR 1.5 (0.98–2.4)	>10 years latency of mobile phone use
				18	OR 1.6 (0.9–2.9)	>10 years latency of ipsilateral mobile phone use
				294	OR 1.1 (0.9–1.4)	>1 year latency, cordless phone use
				23	OR 1.8 (1.01–3.2)	>10 years latency of cordless phone use
				11	OR 3.0 (1.3–7.2)	>10 years latency of ipsilateral cordless phone use
Interphone Study Group [9] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Meningioma ($n=2409$)	1262	OR 0.79 (0.68–0.91)	Regular use of mobile phone in the past ≥1 year
				130	OR 1.15 (0.81–1.62)	Cumulative hours mobile phone ≥1640 h
				21	OR 0.94 (0.31–2.86)	Cumulative hours mobile phone ≥1640 h, tumours in *temporal lobe*
				46	OR 1.45 (0.80–2.61)	Cumulative hours mobile phone ≥1640 h, *ipsilateral* mobile phone use
Interphone [9] Appendix 2			Meningioma ($n=842$)	362	OR 0.90 (0.62–1.31)	Restricted to *ever regular use* time since start 2–4 years; 1–1.9 years as reference entity
				288	OR 0.75 (0.51–1.10)	Restricted to *ever regular use* time since start 5–9 years; 1–1.9 years as reference entity
				76	OR 0.86 (0.51–1.43)	Restricted to *ever regular use* time since start 10+ years; 1–1.9 years as reference entity
				96	OR 1.10 (0.65–1.85)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity

Table 6
Use of mobile phones and meningioma risk, meta-analysis of Hardell, Carlberg [41] and Interphone [9]. Numbers of exposed cases (Ca) and controls (Co) are given.

	Hardell et al.		Interphone		Meta-analysis	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Latency ≥10 years						
-all	38/99	1.52 (0.98–2.37)	110/112	0.83 (0.61–1.14)	148/211	1.10 (0.61–1.99)
-ipsilateral	18/45	1.59 (0.86–2.95)	40/42	0.88 (0.52–1.47)	58/87	1.16 (0.65–2.06)
-contralateral	12/29	1.57 (0.75–3.31)	20/25	0.58 (0.29–1.16)	32/54	0.95 (0.36–2.51)
-temporal lobe	10/99	2.46 (1.08–5.60)	12/12	0.60 (0.22–1.62)	22/111	1.25 (0.31–4.98)
Cumulative use ≥1640 h						
-all	10/43	0.85 (0.41–1.75)	130/107	1.15 (0.81–1.62)	140/150	1.09 (0.80–1.49)
-ipsilateral	6/21	1.11 (0.42–2.88)	46/35	1.45 (0.80–2.61)	52/56	1.35 (0.81–2.23)
-contralateral	3/12	0.98 (0.26–3.61)	28/28	0.62 (0.31–1.25)	31/40	0.69 (0.37–1.27)
-temporal lobe	1/43	0.52 (0.07–3.95)	21/14	0.94 (0.31–2.86)	22/57	0.82 (0.31–2.17)

Random-effects model used for meta-analyses of ≥10 years, based on test for heterogeneity in the overall group. For meta-analyses of ≥1640 h no heterogeneity was found; random- and fixed effects models produced identical results.

3.6. Acoustic neuroma

Acoustic neuroma or Vestibular Schwannoma is a benign tumour that is located in the eighth cranial nerve that leads from the inner ear to the brain. This tumour type does not undergo malignant transformation. It tends to be encapsulated and grows in relation to the auditory and vestibular portions of the nerve. It is a slow growing tumour in the auditory canal but grows gradually out into the cerebellopontine angle with potential compression of vital brain stem centres. Tinnitus and hearing problems are usual first symptoms of acoustic neuroma. Although neuroma is a benign tumour it causes persistent disabling symptoms after treatment such as loss of hearing and tinnitus that severely affect the daily life. The eighth cranial nerve is located close to the handheld wireless phone when used, so there is particular concern of an increased risk for neuroma development due to exposure to RF-EMF emissions during use of these devices.

In the first study by Hardell et al. [15] in Sweden only 13 cases had acoustic neuroma. Five cases reported use of mobile phone, only one with ipsilateral use. The numbers were too low to make meaningful interpretation of an association, Table 7.

Inskip et al. [19] included 96 cases with acoustic neuroma in their US case-control study. No increased risk was found for regular use of mobile phone, Table 7. Duration of regular use ≥5 years gave OR = 1.9, 95% CI = 0.6–5.9. This result was based on only 5 exposed cases and there were no results on long-term use. Furthermore only 1 case had cumulative use >500 h.

Muscat et al. [42] presented results from a hospital based case-control study on acoustic neuroma on 90 (100% response rate) patients and 86 (100%) controls. Mobile phone use 1–2 years gave OR = 0.5, 95% CI = 0.2–1.3 ($n = 7$ cases), increasing to OR = 1.7, 95% CI = 0.5–5.1 ($n = 11$ cases), in the group with 3–6 years use, Table 7. Average use among cases was 4.1 years and among controls 2.2 years.

The pooled analysis of the Hardell group studies yielded in total OR = 2.9, 95% CI = 2.0–4.3 for use of analogue mobile phone and OR = 1.5, 95% CI 1.1–2.1 for use of digital mobile phone [40]. Use of mobile phones gave for acoustic neuroma OR = 1.7, 95% CI = 1.2–2.3 increasing to OR = 2.9, 95% CI = 1.6–5.5 with >10 years latency period, Table 7. Ipsilateral use increased the risk further; in the >10 years latency group to OR = 3.0, 95% CI = 1.4–4.2 [41]. Cordless phone use gave OR = 1.5, 95% CI = 1.04–2.0 increasing to OR = 1.7, 95% CI = 1.2–2.5 for ipsilateral use.

A case-case study on acoustic neuroma was conducted in Japan [43]. The cases were identified during 2000–2006 at 22 participating neurosurgery departments. The diagnosis was based on histopathology or CT/MRI imaging. Of 1589 cases 816 (51%) agreed to participate and answered a mailed questionnaire. A total of 787 cases were included in the final analysis. Two datasets were analysed, one consisted of 362 cases without any tumour related symptoms 1 year before diagnosis, and another consisted of 593 cases without any symptoms 5 years before diagnosis. Cases with ipsilateral use were regarded as exposed and those with contralateral use were assumed to be unexposed and were used as the reference category. Overall no increased risk was found. However, for average daily call duration >20 min with reference date 1 year Risk Ratio (RR) = 2.74, 95% CI = 1.18–7.85 was found increasing to RR = 3.08, 95% CI = 1.47–7.41 with reference date 5 years before diagnosis, Table 7. Unfortunately no results were given for cumulative number of hours for use over the years. For cordless phones no increased risk was found but the analysis was not very informative.

In the Interphone study [10] 1121 (82%) acoustic neuroma cases participated, range 70–100% by centre. Of the controls 7658 (53%) completed the interviews, range 35–74% by centre. The final matched analysis (1:1 or 1:2) consisted of 1105 cases and 2145 controls. Overall no increased risk was found censoring exposure at one year or at 5 years before reference date, OR = 0.85, 95% CI = 0.69–1.04 and OR = 0.95, 95% CI = 0.77–1.17, respectively, Table 7.

Cumulative number of hours of ipsilateral mobile phone use ≥1640 h up to 1 year before reference date gave OR = 2.33, 95% CI = 1.23–4.40 and contralateral use

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Table 7
Summary of studies on the use of wireless phones and acoustic neuroma risk.

Study	Years Study Type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Hardell et al. [15] Sweden	1994–1996; Case-control	20–80 years	Acoustic neuroma ($n=13$)	5	OR 0.78 (0.14–4.20)	>1 year latency of mobile phone use
Inskip et al. [19] USA	1994–1998; Case-control	≥18 years	Acoustic neuroma ($n=96$)	22	OR 1.0 (0.5–1.9)	Regular mobile phone use
				5	OR 1.9 (0.6–5.9)	≥5 years of mobile phone use
Muscat et al. [42] USA	1997–1999; Case-control	≥18 years	Acoustic neuroma ($n=90$)	11	OR 1.7 (0.5–5.1)	3–6 years of mobile phone use
Hardell et al. [40], Hardell, Carlberg [41] Sweden	1997–2003; Case-control	20–80 years	Acoustic neuroma ($n=243$)	130	OR 1.7 (1.2–2.3)	>1 year latency of mobile phone use
				20	OR 2.9 (1.6–5.5)	>10 years latency of mobile phone use
				13	OR 3.0 (1.4–6.2)	>10 years of *ipsilateral* mobile phone use
				4	OR 1.3 (0.4–3.8)	>10 years latency of cordless phone use
				3	OR 2.3 (0.6–8.8)	>10 years latency of *ipsilateral* cordless phone use
Sato et al. [43] Japan	2000–2006; Case-case	All ages	Acoustic neuroma ($n=787$)	97	RR 1.08 (0.93–1.28)	Mobile phone, reference date 1 year before diagnosis, *ipsilateral*
				86	RR 1.14 (0.96–1.40)	Mobile phone, reference date 5 years before diagnosis, *ipsilateral*
				18	RR 2.74 (1.18–7.85)	Mobile phone, reference date 1 year before diagnosis, average daily call duration >20 min, *ipsilateral*
				28	RR 3.08 (1.47–7.41)	Mobile phone, reference date 5 years before diagnosis, average daily call duration >20 min, *ipsilateral*
				45	RR 0.93 (0.79–1.14)	Cordless phone, reference date 1 year before diagnosis, *ipsilateral;* mobile phone non-users
				125	RR 1.02 (0.91–1.17)	Cordless phone, reference date 5 years before diagnosis, *ipsilateral;* mobile phone non-users
Interphone Study Group [10] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Acoustic neuroma ($n=1105$)	643	OR 0.85 (0.69–1.04)	Mobile phone regular use up to 1 year before reference date

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Table 7 (*Continued*)

Study	Years Study Type	Age	Tumour type	No. of exposed cases	Odds ratio, 95% confidence interval	Comments
Interphone [10] 13 countries; Australia, Canada, Denmark, Finland, France, UK, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden	2000–2004, 2–4 years depending on study region. Case-control	30–59 years	Acoustic neuroma ($n=1105$)	304	OR 0.95 (0.77–1.17)	Mobile phone regular use up to 5 years before reference date
				77	OR 1.32 (0.88–1.97)	Cumulative hours mobile phone ≥1640 h up to 1 year before reference date
				36	OR 2.79 (1.51–5.16)	Cumulative hours mobile phone ≥1640 h up to 5 years before reference date
				47	OR 2.33 (1.23–4.40)	Cumulative hours mobile phone ≥1640 h up to 1 year before reference date; *ipsilateral* use
				27	OR 3.53 (1.59–7.82)	Cumulative hours mobile phone ≥1640 h up to 5 years before reference date; *ipsilateral* use
				37	OR 1.93 (1.10–3.38)	Cumulative hours mobile phone ≥1640 h in the past start ≥10 years before reference date
				28	OR 3.74 (1.58–8.83)	Cumulative hours mobile phone ≥1640 h in the past start ≥10 years before reference date, *ipsilateral*
				225	OR 1.41 (0.82–2.40)	Restricted to *ever regular use* time since start 2–4 years; 1–1.9 years as reference entity
				209	OR 1.38 (0.80–2.39)	Restricted to *ever regular use* time since start 5–9 years; 1–1.9 years as reference entity
				64	OR 1.08 (0.58–2.04)	Restricted to *ever regular use* time since start 10+ years; 1–1.9 years as reference entity
				72	OR 1.74 (0.90–3.36)	Restricted to *ever regular use* ≥1640 h, <5 h as reference entity

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OR = 0.72, 95% CI = 0.34–1.53 for acoustic neuroma, Table 7 [10]. For cumulative number of hours of ipsilateral mobile phone use ≥1640 h up to 5 years before reference date OR = 3.53, 95% CI = 1.59–7.82, and for contralateral use OR = 1.69, 95% CI = 0.43–6.69 were obtained. The risk increased further for cumulative ipsilateral use ≥1640 h with start ≥10 years before reference date to OR = 3.74, 95% CI = 1.58–8.83. Contralateral use in that group yielded OR = 0.48, 95% CI = 0.12–1.94, however based on only 4 exposed cases and 9 exposed controls. Overall OR = 1.93, 95% CI = 1.10–3.38 was obtained for long-term use with start ≥10 years before reference date and cumulative call time ≥1640 h.

Similar analyses of the data as in Appendix 2 for glioma [9], yielded highest OR for acoustic neuroma in the shortest latency group, 2–4 years before reference date, OR = 1.41, 95% CI = 0.82–2.40 [10]. Lower OR was calculated in the ≥10 years group, OR = 1.08, 95% CI = 0.58–2.04. Somewhat higher risk than in total, OR = 1.32, 95% CI = 0.88–1.97, was found for cumulative mobile phone use ≥1640 h; OR = 1.74, 95% CI = 0.90–3.36, in this analysis restricted to only regular users. No results were given for ipsilateral use.

3.7. Meta-analysis acoustic neuroma

Table 8 shows results for use of mobile phone and the association with acoustic neuroma based on results by the Hardell group and Interphone study. Random-effects model was used based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups. The same exposure groups as in the meta-analyses of glioma and meningioma were used. For the latency group ≥10 years highest risk was obtained for ipsilateral use, OR = 1.81, 95% CI = 0.73–4.45. The risk increased further for cumulative use ≥1640 h yielding OR = 2.55, 95% CI = 1.50–4.40 for ipsilateral use. The meta-analysis strengthens a causal association between use of mobile phones and acoustic neuroma.

3.8. Other types of brain tumours

Results for other types of brain tumours from the Hardell group diagnosed during 1997–2003 included medulloblastoma ($n = 6$), ependymoma ($n = 19$) and other malignant types ($n = 46$). In total using >1 year latency time no statistically significant increased risk was found for mobile phone use, OR = 1.2, 95% CI = 0.7–2.1 for these tumour types grouped together [41]. However, with >10 years latency the risk increased to OR = 3.2, 95% CI = 1.2–8.8 in total; for ipsilateral use OR = 4.1, 95% CI = 1.03–16. For cordless phone use no statistically significant decreased or increased risk was found (data not in Table). For pituitary adenoma ($n = 34$) and other types of benign brain tumours ($n = 62$) no statistically significant associations were found overall. In the >10 year latency group ipsilateral mobile phone use gave OR = 4.7, 95% CI = 1.1–21 for benign tumours other than pituitary adenoma (central location in the brain and not included in these calculations) but based on only 4 exposed cases. Thus, several of the calculations were based on low numbers.

Takebayashi et al. [44] included 102 cases with pituitary adenoma in the Japanese part of Interphone from December 2000 to November 2004. The response rate was 76%; 102 out of 135 cases. Of the individually matched controls 208 (49%) of 421 participated. In the statistical analysis 161 controls were used to 101 cases; one case was excluded since not diagnosed within study period. Regular mobile phone use yielded OR = 0.90, 95% CI = 0.50–1.61. Cumulative length of use in years or cumulative call time in hours produced no pattern of an association and there was no statistically significant trend. The cut off for highest quartile of cumulative use was 560 h producing OR = 1.33, 95% CI = 0.58–3.09 ($n = 21$ cases, 27 controls exposed). Since pituitary adenoma is a centrally located tumour in the pituitary gland in sella turcica there was no laterality analysis.

In parallel with the Interphone study, pituitary tumours were studied in Southeast England using the same protocol [45]. The inclusion period was from December 2000 until February 2005. In total 506 eligible cases were identified. Of them 317 (63%) were interviewed and 291 (58%) included in the final analysis. Eligible controls from patient lists at general practitioners in the study region were 1464 subjects, and 630 (43%) were interviewed. Regular use of mobile phone gave OR = 0.9, 95% CI = 0.7–1.3. No statistically significant trend for the risk was found for lifetime use in years or cumulative use in hours. For ≥10 years since first use and ≥51 h of cumulative use (median number in that category) OR = 1.6, 95% CI = 0.8–3.6 ($n = 16$ cases, 23 controls exposed) was found.

3.9. Risks to children and adolescents

Children have smaller head and thinner skull bone than adults. Their brain tissue has also higher conductivity and these circumstances give higher absorption from RF-EMF than for adults [6,46,47]. The developing brain is more sensitive to toxins [48] and it is still developing until about 20 years of age [49]. Use of wireless phones is widespread among children and adolescents [50,51]. The greater absorption of RF energy per unit of time, the greater sensitivity of their brains, and their longer lifetimes with the risk to develop a brain tumour leaves children at a higher risk than adults from mobile phone radiation.

The Hardell group has published results for different age groups at the time of diagnosis [52] or age at first use of wireless phones [12,13,28]. Three age groups for first use of a wireless phone were used: <20 years, 20–49 years and 50–80 years. Highest risk for glioma was found for first use of mobile phone or cordless phone before the age of 20 years, Table 9. Thus, mobile phone yielded for glioma OR = 3.1, 95% CI = 1.4–6.7 and cordless phone OR 2.6, 95% CI = 1.2–5.5. The risk increased further for ipsilateral mobile phone use in the youngest age group to OR = 4.4,

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Table 8
Use of mobile phones and acoustic neuroma risk, meta-analysis of Hardell, Carlberg [41] and Interphone [10]. Numbers of exposed cases (Ca) and controls (Co) are given.

	Hardell et al.		Interphone		Meta-analysis	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Latency ≥10 years						
-all	20/99	2.93 (1.57–5.46)	68/141	0.76 (0.52–1.11)	88/240	1.46 (0.39–5.47)
-ipsilateral	13/45	2.97 (1.42–6.21)	44/52	1.18 (0.69–2.04)	57/97	1.81 (0.73–4.45)
-contralateral	6/29	2.38 (0.89–6.35)	17/30	0.69 (0.33–1.42)	23/59	1.22 (0.37–4.11)
Cumulative use ≥1640 h						
-all	10/43	2.86 (1.33–6.14)	77/107	1.32 (0.88–1.97)	87/150	1.81 (0.86–3.81)
-ipsilateral	7/21	3.10 (1.21–7.95)	47/46	2.33 (1.23–4.40)	54/67	2.55 (1.50–4.40)
-contralateral	3/12	2.28 (0.60–8.71)	16/26	0.72 (0.34–1.53)	19/38	1.12 (0.37–3.34)

Random-effects model used for all meta-analyses, based on test for heterogeneity in the overall (≥10 years and ≥1640 h) groups.

95% CI = 1.3–15 for mobile phone use and to OR = 4.3, 95% CI = 1.4–13 for cordless phone use.

Also for acoustic neuroma the risk was highest in the youngest age group with OR = 5.0, 95% CI = 1.5–16 for use of mobile phone increasing to OR = 6.8, 95% CI = 1.4–34 for ipsilateral use. Only one case had first use of cordless phone before the age of 20, so no conclusions could be drawn for cordless phones. Regarding meningioma no clear pattern of age-dependent increased risk was seen.

There are few other studies on brain tumour risk for children from use of wireless phones. Mobikids is one study that is on-going. A multi-centre case-control study was conducted in Denmark, Sweden, Norway, and Switzerland, CEFALO [53]. It included children and adolescents aged 7–19 years and has been commented elsewhere in detail since serious methodological problems exist in the study design and interpretation of the results [54].

In CEFALO a statistically non-significant increased risk for brain tumours among regular users (one call per week for at least 6 months) of mobile phones was found; OR = 1.36, 95% CI = 0.92–2.02. This OR increased somewhat with cumulative duration of subscriptions and duration of calls [53]. No data for long-term use were given; the longest latency period was 5 years. Interestingly, further support of a true association was found in the results based on operator-recorded use for 62 cases and 101 controls, which for time since first subscription >2.8 years yielded a statistically significant OR of 2.15, 95% CI = 1.07–4.29, with a statistically significant trend ($p = 0.001$).

Use of cordless phones was not well assessed. The authors stated that such use was covered only in the first 3 years of use. No explanation was given for this most peculiar definition. Wireless phone use was not considered, that is use of both mobile phones and cordless phones as the relevant exposure category, as used by the Hardell group and adopted by IARC [1]. Instead Aydin et al. [53] included use of cordless phones in the 'unexposed' category when risk estimates were calculated for mobile phone use. Similarly, when use of cordless phones was analysed mobile phone use was regarded as 'no exposure'. Thus, an increased risk was potentially concealed.

The authors summarised that they "*did not observe that regular use of a mobile phone increased the risk for brain tumors in children and adolescents.*" An editorial in the same journal accompanied that conclusion by stating

Table 9
Odds ratio (OR) and 95% confidence interval (CI) for glioma, meningioma and acoustic neuroma in different age groups for first use of the wireless phone [26–28,40]. Numbers of exposed cases (Ca) and controls (Co) are given. Adjustment was made for age, gender, SEI-code, year of diagnosis. For glioma adjustment was also made for vital status.

	Glioma ($n = 1148$)		Meningioma ($n = 916$)		Acoustic neuroma ($n = 243$)	
	Ca/Co	OR, CI	Ca/Co	OR, CI	Ca/Co	OR, CI
Wireless phone (mobile and cordless phone)	670/1267	1.3 (1.1–1.5)	461/1172	1.0 (0.9–1.2)	155/1172	1.5 (1.1–2.0)
<20 years old	25/27	2.3 (1.3–4.3)	6/27	1.0 (0.4–2.6)	5/27	2.4 (0.8–7.3)
20–49 years old	377/746	1.3 (1.1–1.6)	276/711	1.3 (1.02–1.6)	103/711	1.8 (1.2–2.6)
≥50 years old	268/494	1.3 (1.1–1.6)	179/434	0.9 (0.7–1.2)	47/434	1.3 (0.9–1.9)
Mobile phone	529/963	1.3 (1.1–1.6)	347/900	1.1 (0.9–1.3)	130/900	1.7 (1.2–2.3)
<20 years old	17/14	3.1 (1.4–6.7)	5/14	1.9 (0.6–5.6)	5/14	5.0 (1.5–16)
20–49 years old	315/581	1.4 (1.1–1.7)	210/555	1.3 (0.99–1.6)	86/555	2.0 (1.3–2.9)
≥50 years old	197/368	1.3 (1.01–1.6)	132/331	1.0 (0.8–1.3)	39/331	1.4 (0.9–2.2)
Cordless phone	402/762	1.3 (1.1–1.6)	294/701	1.1 (0.9–1.4)	96/701	1.5 (1.04–2.0)
<20 years old	16/16	2.6 (1.2–5.5)	2/16	0.5 (0.1–2.2)	1/16	0.7 (0.1–5.9)
20–49 years old	206/437	1.2 (0.9–1.5)	167/416	1.3 (0.98–1.6)	65/416	1.7 (1.1–2.5)
≥50 years old	180/309	1.4 (1.1–1.7)	125/269	1.1 (0.8–1.4)	30/269	1.3 (0.8–2.1)

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that the study showed "*no increased risk of brain tumors in children and adolescents who are regular cell phone users*" [55]. This was echoed by a news release from the Karolinska Institute in Stockholm claiming that the results of no increased risk were 'reassuring' (http://ki.se/ki/jsp/polopoly.jsp?d=130&a=125250&l=en&newsdep=130). However, these statements go far beyond what the study really showed. In fact, the results indicate a moderately increased risk, in spite of low exposure, short latency period and limitations in study design and analyses. Aydin et al. discussed recall bias – that people tend to overestimate their number of calls – and interestingly they showed that controls overestimated their number of calls more than cases [56]. It was concluded that it was unlikely that a false positive result occurred in CEFALO and that the OR was underestimated for heavy users. Certainly the results in the article [53] cannot be used as reassuring evidence against an association, as discussed in our commentary [54].

3.10. Danish cohort study on mobile phone users

Ideally a cohort study on wireless phone users would be of substantial value. However, several problems exist to establish a cohort with high quality assessed exposure. For example use of both mobile phones and cordless phones vary over time and exposure to RF-EMF emissions also depends on several physical characteristics for different phone types. An attempt to establish a cohort of mobile phone users was made in Denmark in co-operation between the Danish Cancer Society and the International Epidemiology Institute (IEI), Rockville, MD, USA. It was financed by grants from two Danish telecom operation companies (TeleDenmark Mobil and Sonofon), IEI, and the Danish Cancer Society. The source of money for IEI has not been disclosed.

The first results from the Danish study on brain tumour risk among mobile phone subscribers were published in 2001 [57]. It included subjects from January 1, 1982 until December 31, 1995 identified from the computerised files of the two Danish operating companies, TeleDenmark Mobil and Sonofon. A total of 723,421 subscribers were initially identified but the final cohort consisted of only 58% of these subjects. Due to lack of names of individual users 200,507 corporate users were excluded. They were expected to be the heaviest users and such exclusion would underestimate any risk estimates. It should be noted that duration of subscription of a digital phone was at most ≥ 3 years ($n = 9$) and that two thirds of the subscriptions began in 1994 and 1995. In other words, the majority of the cohort members had two years or less of subscription time. This and other shortcomings in this cohort study have been discussed elsewhere in detail [58]. The Danish study was part of the IARC evaluation but it was concluded that the methods used could have resulted in considerable misclassification in exposure assessment [1].

The first update of the Danish study gave follow-up data until 2002 [59]. The median time since first subscription was this time 8.0 years. It was now stated that the cohort members were excluded from the reference population, which seems not to have been the case in the first publication. The Standardised Incidence Ratio (SIR) for glioma was close to unity, SIR = 1.01, 95% CI = 0.89–1.14. The highest SIR was found for glioma in the temporal lobe where RF-EMF exposure from a mobile phone would be highest, SIR = 1.21, 95% CI = 0.91–1.58 ($n = 54$ cases).

After the outcome of the IARC-evaluation was made public in June 2011 [1] two additional reports on the Danish cohort were soon published. Both were new up-dates of mobile phone subscribers and included more information on risk related to longer follow-up. One focused on acoustic neuroma [60] while the other gave results both for all cancers and separately for glioma and meningioma [61].

Approximately 2.9 million of the Danish population of 5.5 million in total was included in the record linkage study on acoustic neuroma [60]. Of the 2.9 million subjects 420,095 were mobile phone subscribers that started their subscription 1987–1995 and in accordance with the aim of the study had lasted for ≥ 11 years, i.e., 1998–2006 during which period the tumour cases were ascertained. No evidence of an increased risk was found for ≥ 11 years of subscription; adjusted Incidence Rate Ratio (IRR) was 0.87, 95% CI = 0.52–1.46.

The analysis of long-term exposure (≥ 11 years) was based on only 15 exposed cases with acoustic neuroma all of which were men. Analysis of tumour size was based on even fewer cases; 8 had a subscription for ≥ 11 years. As for the risk related to laterality Schüz et al. [60] compared the location of acoustic neuroma in long-term mobile phone subscribers with shorter use (<11 years) and non-subscribers to see if tumours occurred more frequently on the side which was assumed to be the mostly exposed. This assumption was based on ecological data from the prospective study, COSMOS, as proxy for laterality [62]. Due to these facts the argument of no laterality risk is not very impressive, especially when applied to only 15 exposed cases.

The fourth report on the Danish mobile phone cohort on tumours of the central nervous system showed no overall increased risk [61]. This was true also when restricted to the individuals with the longest mobile phone use, ≥ 13 years of assumed subscription.

This time the number of the cohort was reduced to 358,403 (49.5%) of the initially identified subscribers ($n = 723,421$). This number was also used in the study on acoustic neuroma [60]. The major additional exclusion ($n = 54,350$) was due to record linkage with the Danish so-called CANULI cohort on socioeconomic factors [63]. That register started 1990 and included subjects from the age of 30. Subscription holders aged 18–29 years were excluded from the mobile phone cohort; this was also the case for the third publication (acoustic neuroma), see above. Follow-up of cancer started at January 1, 1990, or at the age of 30 if occurred later, and ended December 31, 2007.

The study period was 1990–2007 [61] but the cohort was established during 1982–1995. Cancer cases before 1990 were disregarded since the CANULI cohort started in 1990.

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The authors did not discuss the impact of the exclusion of these subscribers on the results. This exclusion would include the early users of analogue phones, which seem to have had higher emissions of RF-EMF than the later digital system. The authors themselves also stated the following in their discussion: "*. . .we found indications that early subscription holders before 1995 were in fact heavier users (based on outgoing calls) compared with all subscription holders in the years 1996–2002.*" Analysis of any early effect in the group who used phones with the highest emissions was most likely hampered. Moreover, also the youngest users, aged 18–29 years that had previously been included, were now excluded from the cohort. The fully adjusted model had no substantial effect on the risk estimates, so results adjusted for age and calendar period should be possible also for the youngest users. The exclusion of young subscribers could be of importance since as discussed above studies have indicated highest risk in subjects that started the use of a mobile or cordless phone before the age of 20 [28,41].

Some of the many shortcomings of the Danish cohort study include: (a) no individual exposure data (e.g. on cumulative exposure, side of head mostly used, and use of cordless phones); including users of cordless phones in the reference category; (b) no control for use of mobile phones in the population after the establishment of the cohort; and (c) no operator-verified data on years of subscription was available. These limitations are likely to have led to an underestimate of any risk in this study. One would expect considerable misclassification of mobile phone use both among subscribers and the reference population since no new subscribers were included in the exposed cohort after 1995.

The publication of the latest update of the Danish study [61] was accompanied by an editorial by Ahlbom and Feychting from the Karolinska Institute in Sweden [64]. It began with the statement: "*Evidence is reassuring, but continued monitoring of health registers and prospective cohorts is still warranted.*" They pointed out methodological advantages, such as elimination of non-response and selection bias, but did forget to mention that less than 50% of the initial cohort remained for analysis. However, they were more lenient on the methodological limitations that they had previously pointed out as serious. In a letter to the Editor in 2007 on an earlier publication of the same cohort [59] they pointed out that several methodological shortcomings undermined the authors' conclusion that "*any large association of risk of cancer and cellular telephone use can be excluded*" [65]. Although more long-term data was now available and adjustment for socioeconomic factors could be made, the update by Frei et al. [61] suffers from basically the same methodological limitations – mainly related to exposure assessment – as the first one did. Instead of addressing the limitations of the Danish cohort study in full, Ahlbom and Feychting [64] used their space to selectively report on results in the Hardell group studies choosing the time period 2000–2003 [23,24] although the whole investigation period was 1997–2003 [27,40]. They discussed incidence data on brain tumours in Sweden instead of Denmark, which would have been more appropriate regarding a Danish cohort study.

The authors of the Danish study have themselves pointed out the main causes of such considerable exposure misclassifications [61]: mobile phone subscription holders not using the phone were classified as 'exposed', non-subscribers using the mobile phone were classified as 'unexposed'; corporate subscribers of mobile phones (200,507 people), which are likely to have been heavy users, were classified as 'unexposed'; persons with a mobile phone subscription later than 1995 were classified as 'unexposed' and users of cordless phones not using a mobile phone were also classified as 'unexposed'.

Other limitations are the absence of analysis by laterality (the side of head where the phone is used in relation to the side of the tumour) and the complete absence of actual exposure data. These and other shortcomings in the cohort study have been discussed elsewhere in more detail [58,65].

It is clear from these limitations that the authors' conclusion that: "*In this update of a large nationwide cohort study of mobile phone use, there were no increased risks of tumours of the central nervous system, providing little evidence for a causal association*" is not soundly based [61].

3.11. Hazard ratio (HR) for survival of patients with glioma

A poorer survival among children with acute lymphoblastic leukaemia exposed to ELF-EMF has been reported in two studies [66,67]. These findings certainly strengthen a causal association between exposure to ELF-EMF and childhood leukaemia. Thus, a carcinogenic effect of RF-EMF emissions would be strengthened if exposure might correlate with survival of glioma patients. To further elucidate that possibility we analysed survival of all cases with malignant brain tumour ($n = 1251$) in our case-control studies [26–28]. Most cases were diagnosed with glioma ($n = 1132$ in this study) so in the following results for glioma are presented in short, for further details see Hardell and Carlberg [68].

Hazard ratio (HR) for survival was close to unity for all glioma cases for use of wireless phones, HR = 1.1, 95% CI = 0.9–1.2. However, latency >10 years increased HR to 1.2, 95% CI = 1.002–1.5. Increased ratio was found for both mobile phone use, HR = 1.3, 95% CI = 1.0005–1.6, and cordless phone use, HR = 1.3, 95% CI = 0.9–1.9. HR increased also with cumulative number of hours of use of mobile phone and cordless phone with statistically significant trend for tertiles ($p = 0.01$) of use of both phone types.

Regarding different types of astrocytoma wireless phone use gave a decreased HR = 0.5, 95% CI = 0.3–0.9 for low-grade astrocytoma, WHO grades I–II. Similar results were found for both mobile and cordless phones. Latency did not change these results. Also cumulative numbers of hours for use yielded decreased HR for both mobile and cordless phone use.

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For anaplastic astrocytoma, WHO grade III, there was no clear pattern of an association for latency or cumulative number of hours for use. On the contrary, for glioblastoma multiforme, WHO grade IV, long-term use >10 years latency of mobile phone increased the ratio, HR = 1.3, 95% CI = 0.9–1.7, and cordless phone, HR = 1.8, 95% CI = 1.2–2.8.

This study showed elevated HR, indicating decreased survival of all glioma cases with long-term and high cumulative use of wireless phones. For astrocytoma WHO grade IV an increased HR was found indicating a survival disadvantage. On the other hand HR was decreased for low-grade astrocytoma, WHO grades I–II, indicating a survival benefit in that group of cases. This could be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis in that patient group [69].

3.12. Brain tumour incidence

It has been suggested that overall incidence data on brain tumours for countries may be used to qualify or disqualify the association between mobile phones and brain tumours observed in the case-control studies [53,64,70,71]. As mentioned above, in support of the cohort findings that Frei et al. [61] presented for Denmark, Ahlbom and Feychting [64] refer to data on overall brain tumour incidence from the Swedish Cancer Registry rather than from the Danish Cancer Registry, which would have been more relevant.

In Denmark a statistically significant increase in incidence rate per year for brain and central nervous system tumours (combined) was seen during 2000–2009; in men +2.7%, 95% CI = +1.1 to 4.3% and in women +2.9%, 95% CI = +0.7 to 5.2% (http://www-dep.iarc.fr/NORDCAN/english/frame.asp). Updated results for brain and central nervous system tumours have been released in Denmark. The age-standardised incidence of brain and central nervous system tumours increased with 40% among men and 29% among women during 2001–2010 (http://www.sst.dk/publ/Publ2011/DAF/Cancer/Cancerregisteret2010.pdf). A more recent news release based on the Danish Cancer Register stated that during the last 10 years there has been an increasing number of cases with the most malignant glioma type, glioblastoma multiforme (astrocytoma WHO grade IV), especially among men (http://www.cancer.dk/Nyheder/nyhedsartikler/2012kv4/Kraftig+stigning+i+hjernesvulster.htm). So far these incidence data are not generally available.

Also in the CEFALO study including Denmark, Sweden, Norway and Switzerland [53] only data from the Swedish Cancer Registry were used on time trends for brain tumour incidence. As we have displayed elsewhere [54] annual change in incidence in the age group 5–19 years differs between the Nordic countries. Thus, for the time period 1990–2008 in Norway a yearly increase in incidence with +3.3%, 95% CI +0.8 to 5.9% in boys and +2.5%, 95% CI +0.2 to 4.9% in girls was seen, whereas in Sweden there was a decline in boys and slight increase in girls. Thus, it would have been more appropriate in CEFALO to discuss trends in all included countries.

The quality of the Swedish Cancer Registry for reporting central nervous system tumours, particularly high-grade glioma, has been seriously questioned [72,73]. In the Deltour et al. [70] article on cancer incidence in the Nordic countries Sweden accounted for about 40% of the population and cases. Thus, under-reporting of brain tumour cases to the Swedish Cancer Register would make the conclusions of the Deltour et al. study less valid.

Little et al. [71] studied the incidence rates of glioma during 1992–2008 in the United States and compared with ORs for glioma associated with mobile phone use in the 2010 Interphone publication [9] and our pooled results published in 2011 [28]. Since our results are discussed and questioned by Little et al., their study needs to be reviewed in more detail. Our response to the journal (BMJ) was never accepted for publication in paper version and cannot be found via PubMed, only on the web (http://www.bmj.com/content/344/bmj.e1147/rr/578564).

First, one important methodological issue that was not stated in the abstract or in Figs. 2–4 in the article by Little et al. [71], but can be found in the web appendix, is that observed rates were based on men aged 60–64 years from the Los Angeles SEER registry as the baseline category. These data were used to estimate rates in the entire dataset, men and women aged ≥18 years and all 12 SEER registries. Thereby numerous assumptions were made as pointed out by Kundi [74] and Davis et al. [75].

Using only men, as Little et al. [71] did, ignores the fact that women had less frequent use of mobile phones than men in our studies, Table 10. Overall 31% of women reported such use versus 57% of men. Furthermore, use varies with age group with a large difference according to age, as we have explored in our publications [28,41]. Thus, the age group 60–64 year old men is not valid to use for these calculations.

Little et al. [71] do not explain how they obtained different results on incidence trends based on the Hardell group results and Interphone on the risk for mobile phone use. They ignored that the Hardell group assessed also use of cordless desktop phones in contrast to Interphone. As pointed out by IARC and the Hardell group the appropriate exposure category for wireless phone RF-EMF is use of both mobile and cordless phones [1]. We have compared our results with Interphone regarding different age groups and exposure categories in these studies. Thereby the results are similar for both study groups [14]. We have now updated the results based on our 2011 publication, Table 11 [14]. We restricted cases and controls to the age group 30–59 years and disregarded use of cordless phones as in Interphone. Odds ratios are in fact somewhat lower in our study than in Interphone. It is thus remarkable that the projected incidence rates by Little et al. are so different based on our results compared with Interphone although ORs are similar. It should be added that Little et al. [71] present

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Table 10
Gender and age distribution for use of mobile phones among glioma cases aged 20–80 years in the Hardell group studies [28]; $n = 1148$.

Age, diagnosis	Men		Women		Total	
	No use/≤1 year latency, mobile phones	Use >1 year latency, mobile phones	No use/≤1 year latency, mobile phones	Use >1 year latency, mobile phones	No use/≤1 year latency, mobile phones	Use >1 year latency, mobile phones
20–24	8	7 (47%)	3	8 (73%)	11	15 (58%)
25–29	10	15 (60%)	5	10 (67%)	15	25 (63%)
30–34	11	26 (70%)	19	8 (30%)	30	34 (53%)
35–39	9	23 (72%)	8	13 (62%)	17	36 (68%)
40–44	10	26 (72%)	16	11 (41%)	26	37 (59%)
45–49	14	37 (73%)	12	16 (57%)	26	53 (67%)
50–54	22	61 (73%)	26	27 (51%)	48	88 (65%)
55–59	35	65 (65%)	59	20 (25%)	94	85 (47%)
60–64	41	51 (55%)	53	15 (22%)	94	66 (41%)
65–69	55	46 (46%)	57	13 (19%)	112	59 (35%)
70–74	43	16 (27%)	41	5 (11%)	84	21 (20%)
75–80	27	8 (23%)	35	2 (5%)	62	10 (14%)
All	285	381 (57%)	334	148 (31%)	619	529 (46%)

wrong latency periods for the results in our studies both in the publication and in the web appendix.

There are several other points that may be added. The results by Little et al. [71] for oligodendroglioma >10 year latency in our study are wrong in the web appendix, should be OR = 2.2, 95% CI = 0.9–5.4 and not OR = 1.4, 95% CI = 0.9–2.3. Another example is that the results for anatomical localisations and tumour grade [in Table 5 in the article] by Little et al. are based on numerous assumptions from SEER data, Interphone and the Hardell group studies. The authors seem not to have paid attention to the fact that the fraction of mobile phone users differs for gender and age groups, see Table 10. Furthermore, in the final Interphone Study Group [9] publication only results for the whole glioma group were presented in contrast to our published results for both low-grade and high-grade astrocytoma [27], results that are ignored by Little et al. We have now analysed the data further using our 2011 publication, Table 12 [28]. Obviously the risk is higher for high-grade (mostly glioblastoma multiforme) than low-grade astrocytoma for latency time >10 years. This is of interest considering the statistically significant yearly increasing incidence of high-grade glioma in the SEER data for 1992–2008, +0.64%, 95% CI = +0.33 to 0.95% published by Little et al. [71] without any further comments. On the contrary, the incidence of low-grade glioma decreased with −3.02%, 95% CI = −3.49 to −2.54%. Increasing yearly trend for glioma in the temporal lobe, +0.73%, 95% CI = +0.23 to 1.23% was also found [71]. Certainly these findings should have been explored in more detail in the study.

In summary the conclusion by Little et al. that "*Raised risk of glioma with mobile phone use, as reported by one (Swedish) study. . .are not consistent with observed incidence trends in the US population data. . .*" goes far beyond scientific evidence and what would be possible to show with the faulty methods used in the study. We agree with Kundi [74] that there is much room for improvement of the BMJ review process, as we have exemplified [54] regarding another recent BMJ publication by Frei et al. [61], as also discussed above.

One should be careful about using data on the incidence of brain tumours, like in Aydin et al. [53] and Deltour et al. [70], to dismiss results in analytical epidemiology. There might be other factors that influence the incidence rate like changes in exposure to other risk factors for brain tumours that are not assessed in descriptive studies. Cancer incidence depends on initiation, promotion and progression of the disease [76]. The mechanism for RF-EMF carcinogenesis is unclear which adds to the view that descriptive data on brain tumour incidence are of limited value.

There are in fact other studies that show an increasing incidence of brain tumours. In Australia the incidence of

Table 11
Odds ratio (OR) and 95% confidence interval (CI) for glioma in the Interphone study [9] and Hardell et al. [14] for the age group 30–59 years. Use of cordless phones disregarded in the Hardell group studies as was done in Interphone. Numbers of exposed cases (Ca) and controls (Co) are given.

	Interphone Appendix 2			Hardell et al.		
	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Unexposed[a]	93/159	(1.0)	–	241/660	(1.0)	–
Latency						
2–4 years	460/451	1.68	1.16–2.41	128/322	1.09	0.84–1.41
5–9 years	468/491	1.54	1.06–2.22	121/258	1.11	0.84–1.47
10+ years	190/150	2.18	1.43–3.31	84/103	1.75	1.23–2.50

[a] Unexposed Interphone Appendix 2: Latency 1–1.9 years; unexposed Hardell et al.: No use + latency ≤ 1 year.

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Table 12
Odds ratio (OR) and 95% confidence interval (CI) for mobile phone use and astrocytoma, cf. Hardell et al. [28].

	>1–5 year latency		>5–10 year latency		>10 year latency		Total, >1 year latency	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Astrocytoma, high grade ($n = 820$)	1.2	0.9–1.5	1.5	1.1–1.9	3.0	2.1–4.2	1.5	1.2–1.8
Astrocytoma, low grade ($n = 132$)	1.4	0.8–2.2	1.3	0.7–2.4	1.7	0.7–4.0	1.4	0.9–2.2

primary brain tumours was studied in two areas, the state of New South Wales and Australian Capital Territory, with about 7 million inhabitants [77]. The study covered the time period 2000–2008 and all diagnoses had a histopathological verification. It included 13 pathology databases servicing 24 neurosurgical centres. Adults aged ≥65 years recorded the largest proportion of malignant brain tumours, 52%. The Annual Percentage Change (APC) for malignant tumours increased statistically significant +3.9%, 95% CI +2.4 to 5.4%. An increase was seen among both men and women. The APC for benign tumours increased with +1.7%, 95% CI −1.4 to +4.9%, thus not statistically significant.

From urban Shanghai an increasing incidence of brain and nervous system tumours for the time period 1983–2007 was reported with APC +1.2%, 95% CI +0.4 to 1.9% in males and APC +2.8%, 95% CI +2.1 to 3.4% in females [78]. No results were given for different tumour types, e.g. malignant and benign brain tumours, or anatomical site. The authors concluded that "*The study did not support an association between cellular telephone use and increased risk of brain and nervous tumours.*" However, that statement goes far beyond what is scientifically justified from this register based study and what was actually investigated.

Certainly it is more informative to analyse incidence trends by anatomical site and histology of the tumour. de Vocht et al. [79] reported in England for the time period 1998–2007 a statistically significant increasing incidence of brain tumours, the majority glioma, in the temporal lobe for men ($p < 0.01$) and women ($p < 0.01$), and frontal lobe for men ($p < 0.01$). The incidence increased also for women in the frontal lobe, although not statistically significant ($p = 0.07$). The incidence decreased in other parts of the brain.

Zada et al. [80] studied incidence trends of primary malignant brain tumours in the Los Angeles area during 1992–2006. APC was calculated for microscopically confirmed histological subtypes and anatomic sub sites. The overall incidence of primary malignant brain tumours decreased over the time period with the exception of glioblastoma multiforme (astrocytoma WHO grade IV). The annual age adjusted incidence rate of that tumour type increased statistically significant in the frontal lobe with APC +2.4% to +3.0% ($p \leq 0.001$) and temporal lobe APC +1.3% to +2.3% ($p \leq 0.027$) across all registries. In the California Cancer Registry the incidence of glioblastoma multiforme increased also in cerebellum, APC +11.9% ($p < 0.001$). In the parietal and occipital lobes or in overlapping lobes no statistically significant changes in incidence were seen. For lower grade astrocytoma decreases of annual age adjusted incidence rates were observed. The authors concluded that there was a real increase in the incidence of glioblastoma multiforme in frontal and temporal lobes and cerebellum. These results by Zada et al. [80] are of interest since the highest absorbed dose of RF-EMF emissions from mobile phones has been calculated to occur in these parts of the brain [6].

It should be noted that also Deltour et al. [70] reported increasing glioma incidence rates in Denmark, Finland, Norway, and Sweden for the time period 1979–2008. APC increased for men with +0.4%, 95% CI +0.1 to 0.6% and for women with +0.3%, 95% CI +0.1 to 0.5%. Unfortunately no data were given for subtypes of glioma and anatomical sites of the tumours, which would certainly have been informative. The authors did not consider these and other limitations when they conclude that "*Our data indicate that, so far, no risk associated with mobile phone use has manifested in adult glioma incidence trends...many increased or decreased risks reported in case-control studies are implausible, implying that biases and errors in the self-reported use of mobile phone have likely distorted the findings.*" It should be noted that regarding Sweden we reported increasing incidence of astrocytoma WHO grades I–IV during 1970–2007. In the age group >19 years the annual change was +2.16%, 95% CI +0.25 to 4.10% during 2000–2007 [41].

4. Discussion

The most comprehensive results on use of wireless phones and the association with brain tumours come from the Hardell group in Sweden and the international Interphone study. As pointed out by IARC [1] other studies as discussed above are too small with short latency times, usually in the range of at most 5 years. Both the Hardell group studies and Interphone give results for latency time of 10 years or more. Thus, a summary evaluation will mainly be based on results from these two study groups.

Both were case-control studies and the cases were recruited during similar time periods, 1997–2003 in the Hardell group and during 2000–2004 in Interphone, with somewhat different years in the varying study regions. There was no overlapping of cases in the Hardell group studies and the Swedish part of Interphone. Cases were ascertained from Regional Cancer Registries in the Hardell group studies and all diagnoses were based on histopathological verification. Thus, all cases had been operated or undergone biopsy of the tumour for diagnosis. In contrast, in Interphone cases were identified from neurological or neurosurgical facilities in the

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study regions; in some centres also from cancer registries. The diagnoses of glioma, meningioma and acoustic neuroma were based on histopathology or diagnostic imaging. It should be pointed out that the diagnosis of both meningioma and acoustic neuroma has a rather high precision using CT and/or MRI. Regarding glioma it is certainly more difficult to establish a valid diagnosis without histopathology, especially when it comes to subgroups such as different grades of astrocytoma (WHO grades I–IV). In the publication by Lahkola et al. [81] most glioma diagnoses were based on histopathology, whereas this has not been published for Interphone in total. It is notable that Interphone [9] has not presented separate results for astrocytoma in total in contrast to the Hardell group. Especially results for high-grade glioma including the most common glioma type, glioblastoma multiforme (WHO grade IV), would be of value since the highest risk was found for that subtype by Hardell et al., Table 12 [27,28]. It is also of interest that we found higher risk for use of mobile and cordless phones for astrocytoma grades III–IV than for grades I–II [82]. Some results were published for glioblastoma multiforme from the 5 North European countries [81]. Certainly the total result for glioma and >10 years since first ipsilateral mobile phone use with OR = 1.39, 95% CI = 1.01–1.92 (p for trend 0.04) would have been of interest for glioblastoma multiforme separately in Lahkola et al. [81].

The Hardell group included cases aged 20–80 years whereas eligible cases in Interphone were aged 30–59 years at diagnosis. This difference is important since the highest incidence of astrocytoma WHO grade IV (glioblastoma multiforme) is found in the age group 45–75 years with mean age 61 years and 80% older than 50 years [83]. As can be seen in Table 10, the highest prevalence of use of mobile phones in the Hardell group studies was up to the age of 54 years, so limiting the age to 59 years as in Interphone diminishes the possibility to find an increased risk taking a reasonable tumour induction period. It seems as if the age distribution in Interphone was more decided by prevalence of mobile phone use in the population than age distribution for glioma cases. Excluding the age group 20–29 years, as in Interphone, makes also an evaluation of young users more difficult, see Table 9.

Meningioma is a slow growing benign tumour with a peak incidence in the sixth and seventh decade of life with a 3:2–2:1 female:male ratio [84]. As pointed out by Interphone [10] the incidence peak of acoustic neuroma is in the age group 50–65 years. Thus, again limiting upper age to 59 years for cases in Interphone excluded a large proportion of cases with meningioma or acoustic neuroma taking a reasonable latency period.

One control subject matched on age, gender and geographical area (region) to each case in the Hardell group studies was drawn from the national population register. The register covers the whole population and each person is assigned a unique id-number making it possible to trace current address for all inhabitants. In Interphone one control was selected for each case from a 'locally appropriate population-based sampling frame'. In Germany the centres used individual matching or frequency matching. The matching variables were age within 5 years, gender and region of residence; in Israel also ethnic origin. When stratified matching was used individual matching was made afterwards from the whole control sample with cases being assigned one control subject (two in Germany) interviewed as close as possible in time to the case [9]. Regarding the Interphone study on acoustic neuroma some centres sampled special controls to the cases, other draw controls from the pool of controls in the glioma and meningioma studies, or used a mixture of both methods.

The Nordic countries have population registers that were used in Denmark, Norway and Finland for recruitment of controls in Interphone. Also Germany used a population register [85]. However, UK used general practioners' lists [86] and in Japan random digit dialling was used [44,87]. Certainly the methods used in Interphone may introduce selection bias. Patient lists are usually selective to use for drawing of controls and do not represent the whole population which is the source of the cases. Also random digit dialling has the potential to introduce selection bias since persons that are registered to subscribe a phone are usually wealthier than non-subscribers. Furthermore, it seems not to be the most appropriate method for selection of controls in a study on mobile phone use, and certainly not regarding cordless phones, since phone subscribers are selected as controls. Furthermore, later selection of controls from a pool with individual matching may give the possibility for selection bias if this is not done in a blinded manner as to exposure status.

These methods contrast to the Hardell group where controls were drawn consequently to the cases and all controls that answered the questionnaire were included in the analyses. In Interphone proxy interviews were performed for 13% of glioma cases but only 1% of controls [9]. This is in contrast to the Hardell group study on deceased cases with malignant brain tumours [26]. Deceased controls were drawn from the Death Registry in Sweden. Relatives to both deceased cases and deceased controls were interviewed, thereby creating the same condition for assessment of exposure among cases and controls. Although using proxy interviews for both cases and controls is the more appropriate method exclusion of proxy interviews in Interphone had little impact on the overall result in the sensitivity analysis.

Use of wireless phones was carefully assessed by a self-administered questionnaire in the Hardell et al. studies. The information was supplemented over the phone by trained interviewers thereby using a structured protocol. This was done blinded as to case or control status. The ear that had mostly been used during calls with mobile phone and/or cordless phone was assessed by separate questions; >50% of the time for one side, or equally for both sides. This information was checked during the supplementary phone calls. Moreover every person that had used a mobile phone received after that a letter asking them again to specify the ear that had been used during phone calls and to what extent that side of the head was mostly used. There was a very good agreement of the results using these three methods to assess these data. Also

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other exposures were assessed in the questionnaire. After the interviews all personal data like names and addresses were removed from the questionnaires so that only an id-number that did not disclose if it was a case or a control was shown. Thus, coding of the data for statistical analysis was performed without personal data on the individual.

We investigated in more detail the possibility of recall and observational bias in our second case-control study [21]. Reporting a previous cancer or if a relative helped to fill in the questionnaire did not change the results, i.e., were no confounding factors. Potential observational bias during phone interviews was analysed by comparing change of exposure in cases and controls after these interviews. No statistically significant differences were found, showing that our results could not be explained by observational bias, for further details see discussion in that publication [21].

On the contrary information on past mobile phone use was mostly collected during face-to-face interviews in Interphone obviously disclosing if it was a case or a control that was interviewed. These interviews were performed by a large number of interviewers at different participating centres. In the personal interviews a computer program that guided the interview with questions read by the interviewer from a laptop computer screen was used. The interviews in the Swedish part lasted for about 45 min. The answers were entered directly into the computer by the interviewer. Cards were shown to if possible identify the model of the mobile phone [88]. The purpose of the study was thereby obviously disclosed to the cases and controls. This was in contrast to the Hardell group mailed questionnaire that contained a large number of other questions without special attention to wireless phones.

We regard hospital based interviews of cases, as in the Interphone study, to be a major disadvantage and ethically questionable. At that time the patient has not fully recovered from e.g. surgery, may not have been fully informed about the diagnosis, treatment and prognosis and may even be under sedation by drugs. Using computer based face-to-face interviews may also be a stressful situation for the patient. In fact patients scored significantly lower than controls due to recalling of words (aphasia), problems with writing and drawing due to paralysis in the Danish part of Interphone [89]. Obviously observational bias could have been introduced by the interview methods in Interphone. Only Finland used a paper version of the questionnaire, but Finland has never published country specific results on the different tumour types, which would certainly have been of interest. For unclear reasons the results on glioma were only included as part of the results for the 5 North European countries [81] and as part of the whole Interphone study [9]. Furthermore, it has not been disclosed how the personal interviews were performed in sparsely populated areas, e.g. in the Northern Sweden. Did the interviewers travel long distances for interviews of controls in rural areas or were all controls living in the largest cities thereby creating selection bias?

It should be noted that the number of participating cases and controls from each centre in Interphone was quite low. It varied for glioma from 60 (Japan) to at most 421 (UK North), for meningioma from 52 (New Zealand) to 350 (Israel) and for acoustic neuroma from 18 (New Zealand) to 152 (UK South). Similarly the number of controls varied according to centre [9,10]. It is obvious that with so low number of interviewed subjects by many different interviewers the quality may have been hampered in Interphone by low training and experience of certain interviewers. Experienced interviewers were defined as those who conducted at least 20 interviews. In fact, in the sensitivity analysis the risk increased for glioma for cumulative mobile phone use $\geq$1640 h from OR = 1.40, 95% CI = 1.03–1.89 to OR = 1.50, 95% CI = 1.10–2.06 if 'experienced interviewers only' were considered. In the Hardell group studies few persons conducted all interviews of the 1251 participating cases with malignant brain tumour, 1254 cases with benign brain tumour, and 2438 controls (total 4942; note one case had both a malignant and a benign brain tumour). All interviewers were first educated; they used a defined protocol and gained considerable experience as interviewers. In fact, they were obliged to carry out the interviews extensively to fulfil the quality in data assessment according to the structured protocol. It is obvious that the few interviewers in the Hardell group study must have been much more experienced than the diversity of interviewers in Interphone. The higher risk restricting analysis to 'experienced interviewers' in Interphone indicates observational bias during assessment of exposure decreasing the risk. Furthermore, 20 interviews as the definition was in Interphone to be an experienced interviewer, is after all a very low number.

Several other sensitivity analyses were performed in Interphone without any major impact on the results. It is discussed in the Interphone study [9] that the increased risk for glioma in the highest decile of cumulative exposure was caused by a number of subjects reporting >5 h call time per day. This number may be real in e.g. certain occupations using the phone as a working tool. Furthermore, if call time was truncated to 5 h per day no statistically significant difference of the risk was found, OR = 1.38, 95% CI = 1.02–1.87 for glioma and OR = 3.03, 95% CI = 1.62–5.67 for acoustic neuroma (exposure up to 5 years before reference date). Certainly it is not justified to exclude these subjects from the analysis as was done in some of the calculations in Interphone [9,10].

It is always essential to have a high response rate in case-control studies to get as valid results as possible. In the Hardell group studies the response rate was 85% (n = 1251) for cases with malignant brain tumour, 88% (n = 1254) for cases with benign brain tumour, and 84% (n = 2438) for controls [29,40]. Lower response rates were obtained in the Interphone study, 64%, range by centre 36–92%, (n = 2765) for glioma cases, 78%, range 56–92%, (n = 2425) for meningioma cases, 82%, range 70–100% (n = 1121) for acoustic neuroma cases, and 53%, range 42–74%, (n = 7658) for controls [9,10]. Certainly these low response rates, less than half of the cases and controls in some centres, may have created the possibility of considerable selection bias and are examples of the multiple methodological problems in Interphone. As has been

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discussed elsewhere not responding controls in Interphone tended to be less frequent users of mobile phone than participating controls leading to underestimation of the risk [32].

There are other differences between the Hardell group studies and Interphone study such as restricting age to 30–59 years in Interphone compared with 20–80 years in the Hardell-group studies and considering use of cordless phones as no exposure to RE-EMF in Interphone. Even if the prevalence of mobile phone use is highest in the age group 30–59 years, excluding older cases diminishes the possibility to find an increased risk, assuming a reasonable latency time. As discussed above the peak incidence of most brain tumours is at a higher age. In a case series from Canada all brain tumours showed a bimodal age distribution with one peak in the 0–4 age group and the other in the 60–69 age group [90]. As shown elsewhere [14] step-wise exclusion of the age group 20–29 years, 60–80 years and including cordless phone use among unexposed reduced OR in the Hardell-group studies to similar results as in Interphone [see Tables 1 and 2 in the publication]. Thus, Interphone seems to have underestimated the risk also for these reasons.

Survival of patients with glioma has only been presented by the Hardell group [68]. Decreased survival of glioma cases with long-term and high cumulative use of wireless phones was found. We found a survival disadvantage for astrocytoma WHO grade IV among cases using mobile phone or cordless phone indicating a worse prognosis in that patient group. On the contrary, a survival benefit for astrocytoma WHO grades I–II was observed. The fact that there was no clear trend with intensity or duration of wireless phone use for low-grade astrocytoma does not speak in favour of an effect of RF-EMF from such use. The exposure might, however, produce awareness bias in these cases. RF-EMF may give tumour promotion [91] inducing disease related personality disturbances and habit changes leading to earlier tumour diagnosis than among unexposed patients. This would result in earlier treatment with a better prognosis after surgery in this patient group [69]. These findings indicate a complex biological effect from RF-EMF exposure and strengthen a causal association between these tumour types, e.g. astrocytoma WHO grade IV (glioblastoma multiforme), and use of wireless phones.

By placing a strong emphasis on incidence data an association between use of wireless phones and brain tumours has been challenged [92]. The authors considered that, if the increased risks seen in case-control studies reflect a causal relationship, there would already be an increase in incidence of brain and central nervous system tumours, for which there seemed to be little evidence. This belief is unfounded for two reasons. The first relates to latent periods for glioma and acoustic neuroma development, typically 10–40 years [93,94]. The results on long-term use of wireless phones are scanty and at most latency period of 10+ years have been studied. Furthermore, we know little about the earliest events in the genesis of glioma in humans for obvious reasons. However, progression of glioma has been studied in large series of tumours of different malignancy grades. Patients with low-grade glioma have been followed with later progression to high-grade glioma [95]. Thus, since the natural history of most glioma from earliest events to clinical manifestation is unknown, but most likely several decades, the exposure duration in most studies is incompatible with a tumour initiating effect. An initiating effect is what would have the most direct effect on the incidence. The other reason concerns the possibility of an effect on tumour development (promotion) and its consequences on the increase in incidence that can possibly occur. If the exposure acts as a promoter, this would decrease latency time for already existing tumours, giving a temporary but not a continuous increase in incidence. In addition it has to be pointed out that any such effect on tumour development is limited by the magnitude of the shift of the age-incidence function and its slope for the respective tumour type [91]. It should be noted that studies on tumour type and anatomical localisation indicate by now an effect from RF-EMF on the incidence of brain tumours [71,77,79,80].

5. Conclusions

There is a consistent pattern of increased risk of glioma and acoustic neuroma associated with use of mobile phones and cordless phones. The epidemiological evidence comes mainly from two study centres, the Hardell group and the Interphone study group. In the same studies by the Hardell group and Interphone study group no consistent pattern of an increased risk was found for meningioma. These results strengthen the other findings, i.e., increased risk for glioma and acoustic neuroma, since a systematic bias in the studies would also have been inherit for meningioma. Furthermore, a causal association between use of mobile phone and glioma and acoustic neuroma comes from the meta-analyses as presented in this publication and also reviewed elsewhere [96]. Supportive evidence comes also from anatomical localisation of the tumour to the most exposed area of the brain, cumulative exposure and latency time that all add to the biological relevance of an increased risk. In addition risk calculation based on estimated absorbed dose gives strength to the findings as well as the impact on survival of glioma patients relating to their use of mobile and cordless phones.

Evidence is increasing that workers with heavy use of wireless phones who develop glioma or acoustic neuroma should be compensated. In fact, the first case with such compensation has now been established in court. The Italian Supreme Court affirmed a previous ruling that the Insurance Body for Work (INAIL) must grant worker's compensation to a businessman who had used wireless phones for 12 years and developed a neuroma in the brain (www.applelettrosmog.it; www.microwavenews.com). He had used both mobile and cordless phones for five to six hours per day preferably on the same side as the tumour developed. The neuroma was located in the trigeminal Gasser's ganglion in the brain. This fifth cranial nerve controls facial sensations and muscles. It is

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the same type of tumour as the acoustic neuroma in the eighth cranial nerve located in the same area of the brain. The Italian case fulfils the criteria for a causal association; more than 10 years use of wireless phones, high cumulative exposure on the same side as the tumour appeared, and a tumour type that would be predicted based on previous research on use of wireless phones and brain tumour risk. No further appeal of the Supreme Court decision is possible.

In summary there is reasonable basis to conclude that RF-EMFs are bioactive and have a potential to cause health impacts. There is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of wireless phones (mobile phones and cordless phones) mainly based on results from case-control studies from the Hardell group and Interphone Final Study results. Epidemiological evidence gives that RF-EMF should be classified as a human carcinogen. The current safety limits and reference levels are not adequate to protect public health. New public health standards and limits are needed.

Authors' contributions

Lennart Hardell was responsible for drafting of the manuscript and Michael Carlberg made all statistical calculations. Michael Carlberg and Kjell Hansson Mild read and gave valuable comments on the manuscript. All authors have read and approved the final version. No conflicts of interest reported.

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LLOYD MORGAN
Exhibit F

Human studies with power density, obtained through personal communication from Dr. Henry Lai, January 8, 2013

	$\mu W/cm^2$	EMF considered	Effects reported
Abdel-Rassoul et al. (2007)	5.4	Mobile phone base station	Neuropsychiatric problems and some changes in the performance of neurobehavioral functions either by facilitation or inhibition.
Augner et al. (2010)	0.21	900-MHz GSM antenna	Psychobiological stress markers
Boscol et al. (2001)	0.5	500 KHz – 3 GHz	Reduce cytotoxic activity in the peripheral blood of women
Chiang et al. (1989)	10	Mainly AM radio	Central nervous and immune systems in man.
Ha et al. (2007)	6.0	AM radio	Childhood leukemia
Heinrich et al. (2010)	>0.4	GSM-900, GSM-1800, WLAN	Headache, irritation, concentration problem
Hutter et al. (2006)	>0.002 (0.002-0.76)	80 MHz – 2 GHz (73% mobile communication signal)	Wellbeing and performance effects at higher exposure levels
Navarro et al. (2003)	0.11	1 MHz – 3 GHz	"RF syndrome"
Thomas et al. (2008)	0.6	GSM-900, GSM-1800, WLAN	"No significant correlation between exposure and syndromes".
Thomas et al. (2010)	>0.4	GSM-900, GSM-1800, WLAN	Behavioral problems in adolescents
Wolf & Wolf (2004)	0.5	850 MHz	An association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Average = 2.2 $\mu W/cm^2$

REVIEWS ON ENVIRONMENTAL HEALTH VOLUME 25, No. 4, 2010

Scientific Panel on Electromagnetic Field Health Risks: Consensus Points, Recommendations, and Rationales

Scientific Meeting: Seletun, Norway, November 17-21, 2009

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Summary: In November, 2009, a scientific panel met in Seletun, Norway, for three days of intensive discussion on existing scientific evidence and public health implications of the unprecedented global exposures to artificial electromagnetic fields (EMF). EMF exposures (static to 300 GHz) result from the use of electric power and from wireless telecommunications technologies for voice and data transmission, energy, security, military and radar use in weather and transportation. The Scientific Panel recognizes that the body of evidence on EMF requires a new approach to protection of public health; the growth and development of the fetus, and of children; and argues for strong preventative actions. New, biologically-based public exposure standards are urgently needed to protect public health worldwide.

Keywords: EMF, wireless telecommunications technology, radiofrequency, non-ionizing radiation, non-thermal effects, long-term effects, public exposure guidelines, public health

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BACKGROUND

In November, 2009, a scientific panel met in Seletun, Norway, for three days of intensive discussion on existing scientific evidence and public health implications of the unprecedented global exposures to artificial electromagnetic fields (EMF).

EMF exposures (static to 300 GHz) result from the use of electric power and from wireless telecommunications technologies for voice and data transmission, energy, security, military and radar use in weather and transportation.

The Scientific Panel recognizes that the body of evidence on EMF requires a new approach to protection of public health; the growth and development of the fetus, and of children; and argues for strong preventative actions. These conclusions are built upon prior scientific and public health reports /1-6/ documenting the following:

1) *Low-intensity (non-thermal) bioeffects and adverse health effects are demonstrated at levels significantly below existing exposure standards.*
2) *ICNIRP and IEEE/FCC public safety limits are inadequate and obsolete with respect to prolonged, low-intensity exposures.*

3) *New, biologically-based public exposure standards are urgently needed to protect public health world-wide.*
4) *It is not in the public interest to wait.*

Strong concern has been voiced by the public, and by scientists as well as public health and environmental policy experts, that the deployment of technologies that expose billions of people worldwide to new sources of EMF may pose a pervasive risk to public health. Such exposures did not exist before the "age of industry and information". Prolonged exposure appears to disrupt biological processes that are fundamental to plant, animal and human growth and health. Life on earth did not evolve with biological protections or adaptive biological responses to these EMF exposures. Exceptionally small levels of EMF from earth and space existed during the time that all life evolved on earth on the order of less than a billionth to one ten-billionth of a Watt per meter squared. A rapidly accumulating body of scientific evidence of harm to health and well-being constitute warnings that adverse health effects can occur with prolonged exposures to very low-intensity EMF at biologically active frequencies or frequency combinations.

The Seletun Scientific Panel has adopted a Consensus Agreement that recommends preventative and precautionary actions that are warranted now, given the existing evidence for potential global health risks. We recognize the duty of governments and their health agencies to educate and warn the public, to implement measures balanced in favor of the Precautionary Principle, to monitor compliance with directives promoting alternatives to wireless, and to fund research and policy development geared toward prevention of exposures and development of new public safety measures.

POINTS OF AGREEMENT

- Global populations are not sufficiently protected from electromagnetic fields (EMF) from emerging communication and data transmission technologies that are being deployed worldwide, affecting billions of people;
- Sensitive populations (for example, the elderly, the ill, the genetically and/or immunologically challenged) and children and fetuses may be additionally vulnerable to health risks; their exposures are largely involuntary and they are less protected by existing public safety standards;
- It is well established that children are more vulnerable to health risks from environmental toxins in general;
- It is established that the combined effects of chemical toxins and EMF together is greater than either exposure alone;
- The Seletun Scientific Panel takes note of international scientific reviews, resolutions and recommendations documenting scientific and public health evidence on EMF exposures;
- The Seletun Scientific Panel notes that complete *"consistency"* of study findings is not to be expected, and it should not be interpreted as a necessary pre-condition for a consensus linking EMF exposure to health impacts. *"Consistency in nature does not require that all or even a majority of studies find the same effect. If all studies of lead showed the same relationship between variables, one would be startled, perhaps justifiably suspicious"* /7/;
- The Seletun Scientific Panel acknowledges that some, but not all, of these exposures support preventative and precautionary action, and the need for more stringent public health limits;
- The Panel takes note of international scientific resolutions and expressions of concern including the Salzburg, Catania, Freiberger Appeal, Helsinki, Irish Doctors (IDEA), Benevento, Venice, London, and Porto Alegre Resolutions (2000-2009);
- The Panel is guided by previously recommended target limits for EMF exposure

in the BioInitiative Report (2007) and the London Resolution (2009);

- The Panel urges governments to adopt an explicit statement that "the standard for judging and acting on the scientific evidence shall be based on prudent public health planning principles rather than scientific certainty of effect (causal evidence)". Actions are warranted based on limited or weak scientific evidence, or a sufficiency of evidence – rather than a conclusive scientific evidence (causation or scientific certainty) where the consequence of doing nothing in the short term may cause irreparable public health harm, where the populations potentially at risk are very large, where there are alternatives without similar risks, or where the exposures are largely involuntary;
- The Seletun Scientific Panel urges governments to make explicit that the burden of proof of safety rests with the producers and providers of EMF-producing technologies, not with the users and consumers.

THE SELETUN SCIENTIFIC PANEL UNANIMOUSLY ENDORSES THESE GENERAL AGREEMENTS AND GENERAL AND SPECIFIC RECOMMENDATIONS

General Agreements from the Seletun Scientific Panel

- The Seletun Scientific Panel has identified specific scientific and public health benchmarks for numeric limits and preventative action that are justified now based on the existing body of evidence;
- The Panel is relying on scientific evidence as the basis for identifying scientific benchmarks establishing EMF levels associated with adverse health effects. The Panel notes that radiofrequent (RF) levels in some regions may already exceed scientific benchmarks for health harm identified here, but political expediency is not the guiding criterion in this assessment;
- EMF exposures should be reduced now rather than waiting for proof of harm before acting. This recommendation is in keeping with traditional public health principles, and is justified now given abundant evidence that biological effects and adverse health effects are occurring at exposure levels many orders of magnitude below existing public safety standards around the world;
- SAR (Specific Absorption Rate) is not an adequate approach to predict many important biologic effects in studies that report increased risks for cancer, neurological diseases, impairments to immune function, fertility and reproduction, and neurological function (cognition, behaviour, performance, mood status, disruption of sleep, increased risk for auto collisions, etc);
- SAR fails to adequately address known effects from modulation.

General Recommendations from the Seletun Scientific Panel

- The Seletun Scientific Panel recommends an international registry be established to track time-trends in incidence and mortality for cancers and neurological and immune diseases. Tracking effects of EMF on children and sensitive EHS populations is a high priority. There should be open access to this information;
- The Panel recommends existing brain tumour registries provide timely age-specific incidence rates. An early indication of brain tumors from mobile (cell) phone use could be in the younger age-specific incidence rates. Where such brain tumors registries to not exist, they should be established;

- Intervention-related epidemiological studies are needed to track the efficacy of intervention(s) that reduce or eliminate exposures to EMF;
- There is a need for mandatory pre-market assessments of emissions and risks before deployment of new wireless technologies. There should be convincing evidence that products do not cause health harm before marketing;
- For occupational exposures, there has been epidemiological evidence as well as clusters and case reports which state the 'case for action' and stringent control measures based on classic industrial hygiene principles (separation, distancing and enclosure). Further, there is need for surveillance markers of hematologic, immunotoxic and chromosome aberrations;
- The Panel discourages use of more lenient safety standards for workers, as compared to the general public. Separate safety limits are not ethically acceptable. Workers include women of childbearing age and men who wish to retain their fertility. Occupational environments where wireless exposures are common may be potentially hazardous to fertility and reproduction (retail and restaurant workers, transit workers, telecommunications and broadcast workers, medical workers, educators, administrators, etc) and those with other exposures or special health risks;
- The Panel strongly recommends that persons with electrohypersensitivity symptoms (EHS) be classified as functionally impaired rather than with 'idiopathic environmental disease' or similar indistinct categories. This terminology will encourage governments to make adjustments in the living environment to better address social and well-being needs of this subpopulation of highly sensitive members of society.

General Research Recommendations from the Seletun Scientific Panel

- Research funding is urgently needed for assays for biological markers [*EMF bioassays as biological markers of EMF dose*] which show promise to measure adverse health effects, and biological effects that, with prolonged or repetitive exposure, can reasonably be presumed to lead to harmful health consequences (biomarkers from cerebrospinal fluid, saliva, immune function changes, and DNA damage to name some);
- The Scientific Panel recommends research funding for studies on bioactive modulation which may, based on current knowledge, cause major consequences at far lower exposure levels based on different exposure parameters including modulation, frequency windows, intensity windows, duration, geomagnetic field and other factors;
- Research is urgently recommended for effects of prolonged or repetitive wireless exposure on children (cancers, neurological diseases, and impairment of cognition, behavior, performance and mood status, and disruption of sleep, etc) ;
- Research in SAR refinements is given a low priority. The scientific panel is in unanimous agreement that SAR is a poor measurement tool. Yet SARs have been used in many key studies reporting increased risk of DNA damage, increased risk for brain cancer, increased risk for acoustic neuroma, and reduced sperm quality parameters, among others. SAR measures only one aspect of exposure and ignores other critical aspects, such as biologically active frequencies (and modulations) that is essential information needed to understand the biological responses induced by EMF over short and long term exposures (e.g., nervous system response and

tissue/organ development, respectively) that does not cause thermal damage so that effective, biologically protective limits can be developed.

Specific Recommendations from the Seletun Scientific Panel

Extremely Low Frequency (Fields from Electrical Power)

- Based on the available evidence, the Seletun Scientific Panel recommends a 0.1 uT (1 mG) exposure limit for all new installations based on findings of risk for leukemia, brain tumours, Alzheimer's, ALS, sperm damage and DNA strand breaks. This exposure limit does not include a safety margin;
- For all newly installed, or newly upgraded electrical power distribution, the Panel recommends a 0.1 uT (1 mG) set-back distance, from residences, hospitals, schools, parks, and playgrounds schools (and similar locations occupied by children) [A 0.1 uT (1 mG) time-weighted average (TWA) using peak loading for transmission lines to ensure that average is about half of this for typical exposures; or equivalent for long-term exposure in interior EMF environments (wiring, trans-formers, appliances, others).];
- For all newly constructed residences, offices, schools (and other facilities with children), and hospitals there shall be a 0.1 uT (1 mG) max. 24 hour average exposure limit;
- For all new equipment (e.g. transformers, motors, electronic products), where practical, the Panel recommends a 0.1 uT (1 mG) max. 24 hour average exposure limit. Where not practical (e.g. large power transformers), there should be a fence, or boundary marker, with clearly written warning labels that states that within the boundary area the 0.1 uT (1 mG) maximum, 24 hour average exposure limit is exceeded;
- The Panel recommends all countries should adopt electrical code requirements to disallow conduction of high-frequency voltage transients back into electrical wiring systems;
- All new electronic devices including compact fluorescent lamps (CFLs) should be constructed with filters to block high-frequency voltage transients from being conducted back onto electrical wiring systems;
- The Panel recommends electric field reductions from electrical wiring in buildings based on evidence of increased cancer risk from prolonged or repetitive electric field exposure. The United States National Electrical Code (NEC) and other governmental codes relating to building design and construction should be revised so that all new electrical wiring is enclosed in a grounded metal shield;
- The United States NEC and other governmental codes that disallow net current on electrical wiring should be better enforced, and ground fault interrupters (GFIs) should be installed on all electrical circuits in order to reduce net current.

Radiofrequency/Microwave Radiation

Exposure Limit Recommendations

Present guidelines, such as IEEE, FCC, and ICNIRP, are not adequate to protect humans from harmful effects of chronic EMF exposure. The existing scientific knowledge is, however, not sufficient at this stage to formulate final and definite science-based guidelines for all these fields and conditions, particularly for such chronic exposure as well as contributions of the different parameters of the fields, e.g. frequency, modulation, intensity, and window effects. The values suggested below are, thus, provisional and may be altered in the future.

- For whole-body (in vivo experiments) or cell culture-based exposure, the Seletun Scientific Panel finds sufficient evidence to establish a

scientific benchmark for adverse health effect at 0.0166 W/kg based on at least 32 scientific studies reporting low-intensity effects (defined as studies reporting effects at exposures of 0.1 W/kg or lower) /8-39/.

- The Panel recommends a provisional whole-body limit of 0.00033 W/kg by incorporation of an additional 50-fold safety margin applied to the scientific benchmark of 0.0166 W/kg. This is consistent with both ICNIRP and IEEE/FCC safety factors. An additional 10-fold reduction is applied to take prolonged exposure into account (because 29 of the 32 studies are acute exposure only), giving a final whole-body limit of 0.000033 W/kg (33 μW/kg). No further safety margin or provision for sensitive populations is incorporated. This may need to be lowered in the future.
- Based on power density measurements, the Seletun Scientific Panel finds sufficient evidence for a whole-body scientific benchmark for adverse health effect exists down to 85 mW/m^2 (0.0085 mW/cm^2 or 8.5 $\mu W/cm^2$) based on at least 17 scientific studies reporting low-intensity effects on humans. Taking more recent human studies conducted near base stations, or at base-station RF levels, Kundi and Hutter /57/ report that the levels must exceed 0.5-1.0 mW/m^2 (0.05 to 0.1 uW/cm^2) for effects to be seen;/40-57/.
- The Panel recommends a provisional whole-body (far-field) limit of 1.7 mW/m^2 (also = 0.00017 mW/cm^2 = 0.17 $\mu W/cm^2$) by incorporation of an additional 50-fold safety margin applied to the scientific benchmark of 85 mW/m^2. This is consistent with both ICNIRP and IEEE/FCC safety factors. This may need to be lowered in the future.
- It can be argued that a further 10-fold reduction is not justified since 13 of the 17 studies are already testing for long-term RF exposure. However, considering that the latest human population studies as reported by Kundi & Hutter (2009) do not show effects below 0.5-1.0 mW/m^2, it can also then be argued that an additional 10-fold reduction on precautionary grounds is justified. If another 10-fold reduction is applied, the recommended level would then be 0.17 mW/m^2 (also 0.000017 mW/cm^2 = 0.017 $\mu W/cm^2$);
- The Seletun Scientific Panel recommends these numeric limits to governments and health agencies for adoption in place of ICNIRP, IEEE/FCC and other outdated public safety guidelines and limits in use around the world. This approach is based on traditional public health principles that support taking actions to protect public health when sufficient evidence is present. Sufficient scientific evidence and public health concern exist today based on increased risk for cancer, adverse fertility and reproductive outcomes, immune disruption, neurological diseases, increased risk of road collisions and injury-producing events, and impairment of cognition, behaviour, performance, mood status, and disruption of sleep;
- Numeric limits recommended here do not yet take into account sensitive populations (EHS, immune-compromised, the fetus, developing children, the elderly, people on medications, etc). Another safety margin is, thus, likely justified further below the numeric limits for EMF exposure recommended here;
- The Scientific Panel acknowledges that numeric limits derived here for new biologically-based public exposure standards are still a billion times higher than natural EMF levels at which all life evolved.

Specific Recommendations for mobile (cell) and cordless phone use

- The Seletun Scientific Panel recommends that users keep mobile (cell) phones away from head and body;
- The Seletun Scientific Panel recommends that users keep mobile (cell) phones and PDAs* switched off if worn or carried in a pocket or

holster, or on a belt near the body. *PDA is generic for any type of Personal Digital Assistant or hand-held computer device;

- The Panel strongly recommends against the use of mobile (cell) and cordless phones and PDAs by children of any age;
- The Panel strongly recommends against the use of mobile (cell) and cordless phones and PDAs by pregnant women;
- The Panel recommends that use of mobile (cell) and cordless phones and PDAs be curtailed near children or pregnant women, in keeping with preventative and precautionary strategies. The most vulnerable members of society should have access to public places without fear of harm to health;
- Public access to public places and public transportation should be available without undue risk of EMF exposure, particularly in enclosed spaces (trains, airplanes, buses, cars, etc) where the exposure is likely to be involuntary;
- The Panel recommends wired internet access in schools, and strongly recommends that schools do not install wireless internet connections that create pervasive and prolonged EMF exposures for children;
- The Panel recommends preservation of existing land-line connections and public telephone networks;
- The Panel recommends against the use of cordless phones (DECT phones) and other wireless devices, toys and baby monitors, wireless internet, wireless security systems, and wireless power transmitters in SmartGrid-type connections that may produce unnecessary and potentially harmful EMF exposures;
- The Panel recognizes that wired internet access (cable modem, wired Ethernet connections, etc) is available as a substitute;
- The Panel recommends use of wired headsets, preferably with hollow-tube segments;
- The Panel recommends avoidance of wireless (Bluetooth-type) headsets in general;
- The Panel encourages the removal of speakers from headsets on wireless phones and PDAs;
- The Panel encourages 'auto-off switches' for mobiles (cells) and PDAs that automatically turn off the device when placed in a holster;
- The Panel strongly discourages the technology that allows one mobile (cell) phone to act as a repeater for other phones within the general area. This can increase exposures to EMF that are unknown to the person whose phone is "piggy-backed" upon without their knowledge or permission;
- The Panel recommends the use of telephone lines (land-lines) or fiber optic cables for SmartGrid type energy conservation infra-structure. Utilities should choose options that do not create new, community-wide exposures from wireless components of SmartGrid-type projects. Future health risks from prolonged or repetitive wireless exposures of SmartGrid-type systems may be avoided by using telephone lines or fiber-optic cable. The Panel endorses energy conservation but not at the risk of exposing hundreds of millions of families in their homes to a new, involuntary source of wireless radiofrequency radiation.

The undersigned recognize the duty of governments and their health agencies to educate and warn the public, to implement measures balanced in favor of the Precautionary Principle, to monitor compliance with directives promoting alternatives to wireless, and to fund research and policy development geared toward prevention of exposure.

The undersigned urge governments and their health agencies to adopt new interim numeric limits and new timetables for implementation of biologically-based precautionary action to limit exposures to EMF.

Agreed 19 November 2009
(as revised through April 20, 2010)
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The London Resolution

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At a scientific conference on 27th November 2007 entitled—"Are Present ICNIRP EMF Exposure Recommendations Adequate?", hosted by Roger Coghill and Robert Verkerk, at the Royal Society, London, scientists endorsed the BioInitiative Report, extended the 2006 Benevento Resolution and resolved that:

"We, the undersigned, do call on the UK Health Protection Agency (HPA), UK Government and all the health protection agencies and governments world-wide, to take note of the findings and recommendations in the Bioinitiative Report (2007) [1] and its predecessors the Benevento Resolution (2006) [2], the Catania Resolution (2002) [3] and the Salzburg Resolution (2000) [4] to immediately reduce the guidelines for exposure to radiofrequency radiation (RF) and extremely low-frequency electromagnetic[1] fields (ELF-EMF) for the following reasons:

- The overwhelming evidence of adverse non-thermal health effects at exposures many times below the current guidelines.
- The near 100% penetration of the market in Europe, the USA and many other markets by mobile phones and increasing penetration elsewhere.
- The vast proliferation of wireless networks and devices beyond those envisaged at the time the current guidelines were set.

We call for the ICNIRP to reconvene as a matter of urgency to reassess the exposure guidelines and to develop and implement biologically based public safety limits reflecting the overall scientific evidence that existing ICNIRP guidelines are not sufficiently protective against health effects from chronic exposures to the rapidly increasing environmental-level ELF-EMF and RF.

Failing that:

- We call for the setting up of an independent body to define new biologically based public exposure limits and/or preventative actions, for ELF-EMF and RF, that address reported biological effects, which, with prolonged exposure, can reasonably be presumed to result in adverse health consequences.
- In the absence of such recommendations we suggest as an intermediate step that the HPA and UK Government immediately implement the ELF-EMF and RF recommendations of the BioInitiative Report 2007 and strive for the recommendations of the Public Health Department of the Government of Salzburg (2002) of 0.06 V/m for outdoor and 0.02 V/m for indoor RF exposure.

Based on the precautionary principle, children and vulnerable groups (such as people with epilepsy and heart conditions) should not be exposed to a risk of harm, thus we propose that

- Children under 16 should use mobile phones and cordless phones for emergency calls only.
- No Wi-fi, WiMax or other forms of wireless networking are placed in homes, schools or public areas or promoted for use thereof.
- That regular and frequent independent audits are undertaken of emissions to ensure that base stations ("masts") do not exceed the new biologically based guidelines at any locality either singly or by accumulation. Such audits should be widely publicised and made available for public scrutiny.

The precautionary principle needs to be implemented."
Signed:

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[1] Magnetic fields at 50–60 Hz.

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[1] BioInitiative Report, http://www.bioinitiative.org/report/docs/report.pdf.
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The Porto Alegre Resolution

We, the undersigned scientists, were honored to participate in a workshop organized by the Universidade Federal do Rio Grande do Sul and the Public Ministry of Rio Grande do Sul and sponsored by the Brazilian Health Ministry, the International Commission for Electromagnetic Safety, the Porto Alegre Environmental Council (COMAM/PA), the Rio Grande do Sul Center for Health Vigilance (CEVS/RS) and others, entitled, "International Workshop on Non-Ionizing Radiation, Health and Environment" which took place on May 18 and 19, 2009, in Porto Alegre, Brazil.

This resolution follows several international resolutions agreed to by concerned scientists and medical doctors over the past decade, including resolutions developed by the International Commission for Electromagnetic Safety [1], based on evidence and consideration on documents such as the BioInitiative Report [2] and a special issue of the journal Pathophysiology on electrical and magnetic fields, published in August 2009 [3].

We agreed that the protection of health, well-being and the environment requires immediate adoption of the Precautionary Principle, which states, "*when there are indications of possible adverse effects, though they remain uncertain, the risks from doing nothing may be far greater than the risks of taking action to control these exposures. The Precautionary Principle shifts the burden of proof from those suspecting a risk to those who discount it*", until new scientific discoveries are recognized as the only criterion for the establishment or modification of non-ionizing radiation exposure standards;

We recognize that, in Brazil as well as all over the world, where there has been an unprecedented explosion in the availability and use of non-ionizing electromagnetic fields for electrical and wireless communications technologies (mobile and cordless phones, WiFi and WIMAX networks, RFID, etc,), as well as major electrical grid and wireless broadband infrastructure changes, this assessment should inform risk management to take proper steps to protect the public from long-term, low-level exposure to extremely-low frequency as well as radiofrequency electromagnetic fields that have substantially increased in the ambient environment in recent years.

We are concerned about the body of evidence that indicates that exposure to electromagnetic fields interferes with basic human biology and may increase the risk of cancer and other chronic diseases. The exposure levels at which these effects have been observed are many times lower than the standards promulgated by the International Commission for Non-Ionizing radiation Protection (ICNIRP) [4] and the IEEE's International Committee on Electromagnetic Safety (ICES) [5]. These standards are obsolete and were derived from biological effects of short-term high intensity exposures that cause health effects by temperature elevation and nerve excitation discovered decades ago. Recent research indicates that electromagnetic fields could cause detrimental health effects even at very low levels of exposure. The ICNIRP and IEEE/ICES standards are being supported and promoted by interested parties to avoid precautionary technical planning, precautionary laws, and precautionary advice to the public.

We are deeply concerned that current uses of non-ionizing radiation for mobile phones, wireless computers and other technologies place at risk the health of children and teens, pregnant women,

seniors and others who are most vulnerable due to age or disability, including a health condition known as electromagnetic hypersensitivity. We strongly recommend these precautionary practices:

1. Children under the age of 16 should not use mobile phones and cordless phones, except for emergency calls;

2. The licensing and/or use of Wi-Fi, WIMAX, or any other forms of wireless communications technology, indoors or outdoor, shall preferably not include siting or signal transmission in residences, schools, day-care centers, senior centers, hospitals or any other buildings where people spend considerable time;

3. The licensing for siting and installation of infrastructure related to electrical power and wireless broadband telecommunications, particularly, cellular telephony, Wi-Fi and WIMAX, should only be approved after open public hearings are held and approval granted with full consideration given to the need to apply the Precautionary Principle. Sensitive areas should be avoided to protect vulnerable populations;

4. Mankind shall be encouraged to continue to discover new means of harnessing non-ionizing electromagnetic energy, aiming at bringing benefits to society, through definition of new standards of human exposure, which are based on the biological realities of nature and not solely on the consideration of economic and technological needs.

We, therefore, urge all nations to join Switzerland, Italy, Belgium, Russia China, the U.S. (for the FCC standard for partial exposure of the head) and other countries and regions that have chosen to adopt a more precautionary strategy, aiming to assure more safety to the public while maintaining good service quality.

We make an urgent call to all nations to convene a panel of experts, selected from candidates recommended by civil society groups (not only those preferred by the affected industries) to discuss precautionary technology, laws and advice in order to develop policies that reconcile public health concerns with further development of wireless communications technology such as mobile phones as well as electric power transmission and distribution systems.

Citations:

[1] ICEM's Benevento Resolution (2006) and Venice Resolution (2008) www.icems.eu.
[2] BioInitiative Report www.bioinitiative.org
[3] A Special Issue of Pathophysiology on the science and public health/policy issues regarding Electromagnetic Fields was published March 2009, and is the only peer reviewed scientific journal referenced on this list. It is now available online at http://www.sciencedirect.com/science/journal/09284680
[4] International Commission on Non-ionizing Radiation Protection www.icnirp.de
[5] Institute of Electrical and Electronics Engineers. www.ieee.org.

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To request that your name be added to this Resolution as a scientist, advocate, organization or member of the general public, we welcome you to notify ICEMS at info@icems.eu.
Please indicate your name, title, affiliation, city and country (1-2 lines at most.)

The Venice Resolution
Initiated by the International Commission for Electromagnetic Safety,
June 6, 2008.

As stated in the Benevento Resolution of September 2006, we remain concerned about the effects of human exposure to electromagnetic fields on health. At the Venice Workshop, entitled, "Foundations of bioelectromagnetics: towards a new rationale for risk assessment and management," we discussed electro-hypersensitivity, blood brain barrier changes, learning and behavioral effects, changes in anti-oxidant enzyme activities, DNA damage, biochemical mechanisms of interaction, biological damage and, experimental approaches to validate these effects. As an outcome, we are compelled to confirm the existence of non-thermal effects of electromagnetic fields on living matter, which seem to occur at every level of investigation from molecular to epidemiological.

An urgent task before international researchers is to discover the detailed mechanisms of non-thermal interactions between electromagnetic fields and living matter. A collateral consequence will be the design of new general public and occupational protection standards. We, who are at the forefront of this research, encourage an ethical approach in setting of exposure standards which protect the health of all, including those who are more vulnerable. We recognize the need for research to reveal the critical exposure parameters of effect and risk from exposure to electromagnetic fields.

The non-ionizing radiation protection standards recommended by international standards organizations, and supported by the World Health Organization, are inadequate. Existing guidelines are based on results from acute exposure studies and only thermal effects are considered. A world wide application of the Precautionary Principle is required. In addition, new standards should be developed to take various physiological conditions into consideration, e.g., pregnancy, newborns, children, and elderly people.

We take exception to the claim of the wireless communication industry that there is no credible scientific evidence to conclude there a risk. Recent epidemiological evidence is stronger than before, which is a

further reason to justify precautions be taken to lower exposure standards in accordance with the Precautionary Principle.

We recognize the growing public health problem known as electrohypersensitivity; that this adverse health condition can be quite disabling; and, that this condition requires further urgent investigation and recognition.

We strongly advise limited use of cell phones, and other similar devices, by young children and teenagers, and we call upon governments to apply the Precautionary Principle as an interim measure while more biologically relevant standards are developed to protect against, not only the absorption of electromagnetic energy by the head, but also adverse effects of the signals on biochemistry, physiology and electrical biorhythms.

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Disclaimer statement: The signatories to these resolutions, have signed as individuals, giving their professional affiliations, but this does not necessarily mean that this represents the views of their employers or the professional organizations they are affiliated with.

Statement on Mobile Phones and the Potential Head cancer risk for the EMF Hearing on EMF, Council of Europe, Paris, February 25th 2011

Professor Jacqueline McGlade, Director, European Environment Agency, and David Gee, Senior Adviser, Science, Policy and Emerging issues

Introduction

We are grateful for this chance to provide some input into this timely hearing on EMF. You are responding to increasing public awareness and concern about the potential hazards of electromagnetic fields, particularly from mobile phones.

The European Parliament[1] has responded to this public concern with a resolution on EMF in 2009 which, among other things, called for lowering exposure to electromagnetic fields and for lower exposure limits that would better protect the public from health hazards. We share these recommendations.

The EP Resolution followed the EEA's first "early warning" on EMF issued in September 2007, which was updated, with a focus on mobile phones and head tumours, in Sept 09[2].

We confine our evidence to a summary of the evidence on mobile phones and head cancer.

Today we would like briefly:

- to describe the role and mandate of the EEA;
- to summarise our views about some of the benefits and potential costs to health of mobile phones;
- to share with you some practical implications of the current evidence on the head cancer risks from using mobile phones, especially for children and young adults; and
- to conclude with brief observations about three relevant and more general issues: transparency in the evaluation of scientific evidence; the adequacy and funding of independent research into

[1] European Parliament resolution of 2 April 2009 on health concerns associated with electromagnetic fields (2008/2211(INI))

Statement on Mobile Phones for Conference on Cell Phones and Health: Science and Public Policy Questions, Washington, 15 September 2009, Professor Jacqueline McGlade, Director, European Environment Agency, Denmark.

environmental and health hazards; and the harassment of early warnings scientists.

We have also tried to provide this information in ways that would help improve the understanding of how other potential environmental stressors can be identified, evaluated, and minimised.

The role of the EEA and past work on the precautionary principle

The EEA provides data, information and knowledge on the environment, including its impacts on public health, to EU institutions (the European Parliament, European Commission, and European Council of Ministers), to the 32 Member Countries of the EEA, and to the general public .

The EEA does not routinely carry out *specific* risk assessments on individual hazardous agents, such as radio frequencies from mobile phones. However, the EEA does have relevant knowledge and expertise about the way in which the overall scientific evidence on hazards and risks is evaluated.

Some of this knowledge is to be found in the EEA Report, 'Late Lessons from Early Warnings: the Precautionary Principle 1896–2000' published in 2001. This report reviews the histories of a selection of public and environmental hazards, such as asbestos, benzene, X rays, acid rain, and PCBs. These histories run from the first scientifically based early warnings about potential harm to subsequent inactions, or to precautionary, and then preventative, measures.

The EU Commission and the EEA sees the precautionary principle as central to public policymaking where there is scientific uncertainty and high health, environmental and economic costs in acting, or not acting, when faced with conflicting evidence of potentially serious harm.

This is precisely the situation that characterises EMF at this point in its history. Waiting for high levels of proof before taking action to prevent well known risks can lead to very high health and economic costs, as we have seen with asbestos, leaded petrol and smoking.

For example, taking effective *precautionary* action to avoid the *plausible hazards* of smoking in the late 1950s or early 1960s would have saved much harm, health treatment costs, and productivity losses from smoking. Waiting to *prevent* the then *known risks* of smoking in the 1990s, or later, incurred very these large costs to smokers, their families, and taxpayers.

Both the precautionary and preventative principles, along with the principles of the polluter pays and the reduction of hazards at source, are provisions of the EU Treaty, and all are applicable to health, consumer, and environmental issues, such as EMF.

Over 60 international treaties, including the Third North Sea Ministerial Conference, 1990, have included reference to the precautionary principle, or to the precautionary approach. A recent legal review points out that there is little, if any, practical difference between these two concepts[3].

However, there remains an absence of a clear and comprehensive definition of the precautionary principle at EU level. The EEA, in response to the debates on the precautionary principle since its 2001 report, has produced a working definition:

'*The Precautionary Principle provides justification for public policy actions in situations of scientific complexity, uncertainty and ignorance, where there may be a need to act in order to avoid, or reduce, potentially serious or irreversible threats to health or the environment, using an appropriate strength of scientific evidence, and taking into account the pros and cons of action and inaction*'

The definition is proving useful in promoting a shared understanding of the precautionary principle. It is explicit in specifying both uncertainty and ignorance as contexts for applying the principle; it is couched in the affirmative rather than the negative; and it explicitly acknowledges that a case specific sufficiency of scientific evidence is needed to justify public policy actions, given the pros and cons of action or inaction.

The definition also explicitly widens the conventionally narrow, and usually quantifiable, interpretation of costs and benefits to embrace the wider and sometimes unquantifiable, "pros and cons". Some of these wider issues, such as loss of public trust in science, are unquantifiable, but they can sometimes be more damaging to society than the quantifiable impacts: they therefore need to be included in any comprehensive risk assessment. (See chapter on BSE in "Late Lessons from Early Warnings", EEA 2001).

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[3] A.Trouwborst, The Precautionary Principle in General International Law: Combating the Babylonian Confusion, RECEIL, 16(2) (2007) p185-195.)

The Benefits of mobile phones and potential hazards of EMF

The EEA greatly appreciates the benefits of mobile phone telephony. Indeed, the Agency is actively encouraging it as a means of communicating environmental and related information to the public.

We have ambitious plans, for example, to help 'citizen scientists' to collect data on environmental parameters, such as bird movements, fish stocks, water quality, the flowering season, and alien species, and to communicate such data ,via mobile phones, to central data banks such as those hosted by the EEA and others.

Our promotion of this use of mobile telephony increases our responsibility to provide information that can help ensure the safety of the public when using mobile phones, especially the more vulnerable groups in society such as children, the elderly, pregnant women, and the immuno-compromised.

This is one of the reasons why the EEA issued an "early warning" about the potential hazards of EMF on 17 September 2007, and updated it with a focus on mobile phones on September 15 2009.

In these statements we drew attention to the "BioInitiative" report and to the other main sources of evidence relevant to this debate, from the EU, the WHO, the UK National Radiological Protection Board, and to the special issue on EMF of the journal of The International Society for Pathophysiology[4]-all of which are cited in the References below.

Taken together this evidence provided the basis for our early warnings.

Based on our experience with the "Late Lessons from Early Warnings" reports (EEA, 2001 & 2011, forthcoming) we noted in 2007 that:

'There are many examples of the failure to use the precautionary principle in the past, which have resulted in serious and often irreversible damage to health and environments.
Appropriate, precautionary and proportionate actions taken now to avoid plausible and potentially serious threats to health from EMF are likely to be seen as prudent and wise from future perspectives".

[4] Physiopathology, Special Issue on EMF, Vol 16, Issues 2-3, August 2009.

Jacqueline McGlade, Sept 17th 2007, EEA website.

In 2009 we said that:

"The evidence for a head tumour risk from mobile phones, although still very limited, and much contested, is, unfortunately, stronger than two years ago when we first issued our early warning".

The evidence is now strong enough, using the precautionary principle, to justify the following steps:

1. *For governments, the mobile phone industry, and the public to take all* ***reasonable measures to reduce exposures to EMF, especially to radio frequencies from mobile phones, and particularly the exposures to children and young adults who seem to be most at risk from head tumours.*** *Such measures would include stopping the use of a mobile phone by placing it next to the brain. This can be achieved by the use of texting; hands free sets; and by the use of phones of an improved design which could generate less radiation and make it convenient to use hands free sets*[5].
2. ***To reconsider the scientific basis for the present EMF exposure standards which have serious limitations*** *such as reliance on the contested thermal effects paradigm; and simplistic assumptions about the complexities of radio frequency exposures.*
3. *To provide* ***effective labelling and warnings*** *about potential risks for users of mobile phones.* Across the European Union, the vast majority (80%) of citizens do not feel that they are informed on the existing protection framework relating to potential health risks of electromagnetic fields. 65% of citizens say that they are not satisfied with the information they receive concerning the potential health risks linked to EMF. (Special Euro barometer report on EMF, Fieldwork Oct/Nov 2006, published 2007).
4. *To* ***generate the funds needed to finance and organise the urgently needed research*** *into the health effects of phones and associated masts.* ***Such funds could include grants from industry and possibly a small levy on the purchase and or use of mobile phones.*** *This idea of a research levy is a practice that we think the US pioneered in the rubber industry with a research levy on rubber industry activities in the 1970s when lung and stomach cancer was*

[5] We have since noted ,with some relief, what appears to be an increased use of hands free devices, particularly in the younger generation, due to enhanced applications.

an emerging problem for that industry. ***The research funds would be used by independent bodies[6].***

Mobile phones & Head tumours: main features of the current evidence

There are essentially four types of evidence that can be available to help us make decisions about hazards to health that may arise from environmental stressors: **epidemiological** (studies of the distribution of exposures and disease in people); **experimental, with live animals** (studies of exposure, disease and mechanisms of biological actions in rodents ,rabbits etc) ; **experimental, with biological cells and tissues** (studies of biological activity and responses to stressors); and **experiential,** ie learning from history and its events that may be analogous to the potential stressor being evaluated.

Taken together these lines of evidence about a potential environmental stressor (such as radiations, noise, chemicals, dusts, temperature etc., and of the mixtures of these, which is the relevant reality most of the time) could support a conclusion of **causality,** when the evidence is very strong from all four types, to **no causality,** when the *evidence* (as opposed to mere *absence of evidence*) is strongly against a link between environments and health.

In between these two extremes lies a continuum of evidence from a **scientific suspicion of risk** to **very strong associations** between the environmental stressors and harm

The overall **strength of evidence** that is deemed sufficient to justify specific decisions varies with the circumstances of each case.

For example:

- **very strong evidence** is usually needed to justify condemning a criminal to death or lifelong jail;
- a **medium "balance of evidence"** is usually sufficient to justify awarding compensation to injured people; or claiming that humans are disturbing the climate (IPCC, 2001);
- and **slight evidence** of a serious illness is usually sufficient for a doctor to prescribe some medical intervention; or for a regulatory

[6] We have noted the increasing evidence of "funding bias" in scientific research whereby results outcomes are strongly linked to source of funding. This observation is based on evidence from pharmaceuticals, tobacco, lead, asbestos, BPA, and EMF, as well as on evidence from other fields such as CBA and Transport construction project cost estimations.

authority to ban some potentially serious activity, such as the US ban on imported beef that may carry BSE; or a ban on a pregnancy pill for which there is a suspicion of potential damage to the foetus.

It follows from the above that statements such as *"there is no convincing evidence that X causes Y"* (frequently found in reviews of evidence) are devoid of practical meaning, unless the implicit assumption, which is buried in that statement, is made explicit ie that the evidence for ***causality*** **(the highest strength possible)** is not convincing to the scientists making that statement.

The **choice of which strength of evidence is appropriate for a specific stressor and types of precautionary actions is an ethical issue** that turns upon the costs (quantitative and qualitative) of being wrong in acting or not acting.

For example, Sir Bradford Hill in his classic paper on association or causation in environmental disease written at the height of the smoking controversy in the mid 60s, proposed that "relatively slight evidence" of serious harm would be sufficient to justify banning a potentially teratogenic pregnancy pill, where the costs of being wrong in so acting would be much lower than the costs of being wrong in not acting to prevent exposure. (The thalidomide tragedy in the early 60s and the DES[7] tragedy of the 70s provide powerful analogous evidence when dealing with potential teratogens and other developmental and reproductive hazards. This is an example of "experiential" evidence).

In contrast, Bradford Hill suggested that a much higher strength of evidence would be needed to justify the government banning the voluntary acts of smoking, or eating fatty foods.

Given the serious and largely irreversible nature of the brain tumour risk from mobile phones, it would be appropriate to take action on relatively weak evidence for an effect.

It should also be noted that the *strength of evidence* does not determine the *strength of a recommendation for action.*

For example, there is very strong evidence that cars kill a lot of people but there are no strong society wide recommendations for a total ban on cars because of the large benefits that they bring; and a doctor would

[7] See chapter on DES in "Late Lessons from Early Warnings", EEA ,2001.

strongly recommend a particular medicine that had proven to be effective in preventing or curtailing a disease when the evidence for an impending but serious disease may be quite weak in that patient. (The widely adopted GRADE scheme for the evaluation of the evidence for pharmaceutical products and clinical interventions also makes this distinction between strengths of evidence and of recommendations, as does the European Centre for Disease Control).

Whilst the evidence on the head cancer risk from mobile phones is not currently very strong the recommendations on exposure reduction that flows from this evidence, cited above, can be very strong, given their low cost efficacy.

The Nature and Strength of the current evidence on mobile phones and head cancers

Epidemiological Evidence

We were hoping to see by now clear evidence that mobile phones are safe to use, particularly by children, as they absorb more radiation in their heads than adults, from the same phone exposure, and are more sensitive to that radiation.

Unfortunately, the epidemiological evidence for a head tumour risk from mobile phones, although still very limited, and much contested, is, unfortunately, stronger than in 2007 and 2009 when we issued our early warnings on EMF, particularly focused on RF from mobile phones and its possible link to head cancers.

The latest reviews of both the Hardell studies[8] and the Interphone[9] studies on brain cancers from mobile phones have noted their consistency when the analysis is rightly focused on the most likely at risk group ie those with longer than 10 years of exposure, where there is an approximately 1.5-2.0 fold increase in head cancers, particularly on the side of the head where the phone is most used.

The Cardis and Sadetzki review, published this month, is particularly relevant as the lead author, Cardis, was the Interphone study coordinator

[8] Hardell, L. "Non Thermal effects and Mechanisms of interaction between Electromagnetic Fields and living matter", eds Guiliani L and Soffritti, M, ICEMS, Ramazzini Institute, Bologna, Italy., 2010. p 363.

[9] Cardis, E. Sadetzki S., "Indications of possible brain tumour risk in mobile phone studies: should we be concerned?". Occup. Environ Med., March 2011 vol 68, No 3, p 169-171, downloaded Feb 15 2011.

when working at the WHO International Agency for Research on Cancer, and her co-author is another Interphone study participant.

They review both the Hardell and Interphone results and conclude, after a full discussion of the methodological strengths and weaknesses of the studies, that:

"It is not possible to evaluate the magnitude and direction of the different possible biases on the study results and to estimate the net effect of mobile phones on the risk of brain tumours.
The overall balance of the above mentioned arguments, however, suggest the existence of a possible association".

They conclude by recommending:

"Simple and low cost measures, such as the use of text messages, handsfree kits and/or the loudspeaker mode of the phone could substantially reduce exposures to the brain from mobile phones. Therefore, until definitive scientific answers are available, the adoption of such precautions, particularly among young people ,is advisable."(p 170).

A recent paper from Japan[10] was not included in the review by Cardis, but it too found an increase risk for acoustic neuromas in the longer exposed groups. They concluded:

"The increased risk should be interpreted with caution, taking into account the possibilities of detection and recall biases. However, we could not conclude that the increased risk was entirely explicable by these biases, leaving open the possibility that mobile phone use increased the risk of acoustic neuroma".

This paper is also significant because it comes from the same country Interphone study team which did not find evidence of head cancers in its earlier report several years ago-time has probably been the main factor in now revealing this slightly positive effect.

If the brain cancer risk from mobile phones is real, and we want to prevent, as opposed to merely count, cancers, then there is now sufficient evidence to justify reducing exposures, especially in children, as

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[10] *Yasuto Sato et al., Bioelectromagnetics 32:85–93, 2011..*

recommended by the UK Radiological Protection Board Stewart Report 8 years ago.

As the Interphone report is confined to those aged over 30 at the start of the study we must wait for the results of the Mobikids[11] Study funded, by the EU, before we have any results on possible cancer effects in children and young people.

However, it is of particular concern that the increased risk for the under 20 at first exposure group in the Hardell studies display a 5 fold increase in risk, compared to the roughly 1.5- 2 fold risk for the average of all long term users.

Finally on the epidemiology, although the overall trends in specific cancer rates can be a poor guide to the presence of cause/effect links (because of other causes of the same cancer, long latency, and small numbers of exposed in the early days) it is of some concern that the trend in cancer of the paratid gland, which is adjacent to the head location of the mobile phone, in Israel is rising now rising[12], with the steepest rise after 200, whilst other salivary gland tumours have remained stable; and the trend of brain cancers in Sweden appears to be rising[13]. Both Israel and Sweden are amongst the heaviest and earliest users of mobile phones.

Experimental Evidence

The evidence from experimental studies in animals and cells is largely confined to short term studies of non cancer biological effects and to mechanisms of biological actions. The long term studies of ELF and RF are rare, methodologically weak, and largely negative. The exception is the recent large scale and foetal to mortality rat study by the Ramazzini Institute[14]. Preliminary results show an increase in mammary gland tumours from the combination of ELF and gamma radiation.

This evidence on these non thermal effects of ELF and RF has been recently and comprehensively reviewed by the Ramazzini Institute[15]. It contains much detailed evidence which, taken as a whole, provides

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[11] Contact ecardis@creal.cat for details.

[12] Czerninski et al, "Risk of Paratid Malignant Tumours in Israel (1970-2006)", Epidemiology, Jan 2011, v 22, Issue 1, p130-131

[13] Hardell , ref 8.

[14] Soffritti M et al, "Mega-experiments on the cacinogenicity of ELF Magnetic fields" . Chapter In ref 15.

[15] "Non Thermal effects and Mechanisms of interaction between Electromagnetic Fields and living matter", eds Giuliani L and Soffritti, M, ICEMS, Ramazzini Institute, Bologna, Italy., 2010.

further grounds for heeding the early warnings and taking the precautionary measures outlined above.

It is sometimes claimed that:

- the scientific basis for the current ICNIRP limits for exposure to EMF are safe;
- that children are no more sensitive than adults to the RF from mobile phones;
- that there are no biologically significant effects from non thermal levels of EMF, and
- that, if there are such effects, there are no acceptable mechanisms of action that could explain these effects.

However the recent 400 page review by the Ramazzini Institute and ICEMS provides a wealth of evidence to the contrary.

Its main findings are therefore summarised in the **Annex** to this evidence.

Transparency in the Evaluation of Evidence

We are pleased that Chris Wild, Director of IARC, finally managed, in 2010, to get the Interphone study published after 4 years delay, apparently caused principally by the 13 scientists who were unable to agree on interpretations of the results.

However, we were disappointed that the large differences of interpretation within the group of Interphone scientists about the strength, direction and implications of methodological biases were not clearly explained in the published report.

In 2009, the EEA asked Chris Wild to make these differences of interpretation transparent when they published their report so as to help decision makers and the public better understand how different scientists can come to very different conclusions about the same data.

There are at least 4 possible interpretations of the Interphone or any similar type of study: there is no link between mobile phones and brain cancer; the few suggestive results of a risk are the result of biased methodology; the links are just random; or they are indicative of a true risk.

It would have been helpful to see which of the scientists who authored the Interphone paper thought what, and for which reasons, when it was

published in 2010. Not doing so caused the kind of confusion amongst journalists, policymakers and the public that we had predicted.

For example, from media reports (Microwave News May 17th), we learn that Cardis, the coordinator of the Interphone study, thought that "overall..the results show a real effect"; Armstrong thought that "it shows some indication of a risk of gliomas but I cannot say this with certainty"; and Sadetzki thought the results have consistency in indicating a risk but whilst not "strong enough for a causal interpretation they are sufficient to support precautionary policies". In contrast, another co-author ,Feychting, thought that "the use of mobile phones for over ten years shows no increased risk of brain tumours".

(Feychting and Ahlbom, another Interphone author, took part in a press conference at their Institute a day before the IARC embargoed release date for the study, which seemed to compound the confusion, at least in Sweden.)

Without the detailed transparency and honest dialogue about opposing views and their rationale that we called for in 2009, the public had to work it out for themselves via the rival media statements from the different Interphone factions, and varying journalistic interpretations, which appeared on publication of the results. (See the opposing headlines in the Daily Telegraph (there is a risk) with BBC News (there is no risk) on the same day of May 15, 2010, when the Interphone results were published.

We therefore strongly re-iterate our plea for greater transparency in the reporting of different interpretations of controversial data. This would also help clarify and better communicate the nature of the methodological and intellectual biases in all studies, which, along with periodic funding bias, contributes to differing evaluations of evidence and to controversy.

Adequate independent research into potential hazards to environment and health.

If the public and environment are to be adequately protected from hazards of new technologies there needs to be sufficient independent research into potential risks early enough to prevent them. We are concerned that over the last three decades there have been large reductions in independently funded scientific research on environmental and related health risks compared to privately funded research on developing the new technologies.

For example, compare the excess of £220m spent on applications of nanotechnologies by the UK Engineering and Physical Sciences Research Council with less than £20m on the potential environment, health and safety hazards from nanotechnology by MRC and other government funded bodies, between 2004-2009. [16]

Meanwhile, industries are not forthcoming in releasing key risk data on, for example, GMOs[17] and nanotechnology[18]. In some areas, such as electro-magnetic fields[19] and GMOs[20] , significant barriers to independent research have also been created.

This not only leaves the public and the environment vulnerable to new hazards but the new technologies can themselves become vulnerable to premature restriction if hazards are not foreseen and minimised.

Harassment of "Early Warning" Scientists.

It is important for society, science, and public health that scientists who bring early warnings of possible later harm are encouraged, rather than harassed.

It is disturbing to see that ever since Galileo was persecuted for publishing his "Starry Messenger" just 400 hundred years ago, claiming that the sun and not the earth was at the centre of the universe, those who prefer not to hear "inconvenient warnings" have tried to "shoot the messenger" rather than deal openly with the strengths and weaknesses of the new message.

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[16] (UK House of Lords Science & Technology Committee report on Nanotechnologies and Food, 8 Jan 2010, para 4.46.).

[17] In order to access Monsanto test data on the safety of a GM product, submitted to EFSA, independent scientist had to use the German courts to access and verify the data. De Vandemois et al, "Debate on GMOs Health Risks after Statistical Findings in Regulatory Tests". Int J.Bio.Sci.,2010,6.

[18] The UK House of Lords report : "criticises the food industry for failing to be transparent about its research into the uses of nanotechnology and nanomaterials". Ref 16.

[19] "This approach (long term cohort studies) was blocked in the USA through litigation". Saracci R, Samet, J, "Commentary: a look at the Interphone study results", In J Epidemiology, 2010,1-4, May 18, 2010.

[20] See letter from 24 leading corn insect scientists to the US EPA concerning the way GMO technology agreements "explicitly prohibit research", Feb 19, 2010. Their names had to be withheld "because all of us require cooperation from industry at some level to conduct our research". See "Conducting public sector research on commercialised transgenic seed", Sappington et al, www.landbioscience.com v. 1, issue 2, 2010, Mar/April

In our reports on "Late Lessons from Early Warnings"[21] we have observed how early warning scientists in the lead and mercury stories have been harassed, frequently suffering from discrimination, from loss of research funds, and from unduly personal attacks on their scientific integrity.

This practice of harassment appears to be is continuing with scientists studying Climate Change[22], GMOs[23], and electro-magnetic fields[24] . Scientific associations, lawyers, and politicians should therefore consider ways in which societies could provide greater protection for early warning scientists.

An interesting precedent has been set in Germany, where the Federation of German Scientists has been recognising the contribution that 'whistle blowing' scientists and others can make to robust and transparent democracies. Although "early warning" scientists are not reporting on whistleblowing activities, which often involve criminal actions, principle of their protection is the same.

Conclusion.

We hope that there turns out to be no cancer risk, or indeed any risk from using mobile phones, and that our early warnings, which some might say are already a decade or so too late, will be proven unnecessary. However, we would rather be wrong in issuing an unnecessary warning than be wrong in failing to alert the public about potentially serious, irreversible harm in time to avoid such harm: especially as we are promoting mobile telephony through "citizen science".

Three main scenarios seem to face us all with EMF, particularly with the RF from mobile phones. The first is similar to the case studies in the EEA reports on "late lessons", where inaction caused much avoidable harm. The second is where precautionary actions to reduce EMF exposures avert much potential harm, whilst stimulating more sustainable

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[21] "Late Lessons from Early Warnings: the Precautionary Principle 1896-2000", (EEA 2001), Vol 2 appears in late 2011.

[22] See the recent letter from many scientists to the "Science" journal who "are deeply disturbed by the recent escalation of political assaults on scientists in general and on climate scientists in particular". www.sciencemag.org SCIENCE VOL 328 7 MAY 2010

[23] See press release from the European Network of Scientists for Social and Environmental Responsibility, (ENSSER) May 10, 2010 www.ensser.org; and claudia.neubauer@sciencescitoyennes.org;

[24] Louis Slesin , producer of Microwave News ,has details of those EMF scientists who have suffered for their views. Louis Slesin [mwn@pobox.com]

innovation in the production and use of mobile phone technologies and energy systems. And the third is where such precautionary actions to reduce exposures are taken but they turn out to have been unnecessary, if reasonable, given the state of knowledge today.

The choice that now faces us is whether or not to act.

Thank you for your attention.

Professor Jacqueline McGlade, Executive Director of the European Environment Agency, and David Gee, Senior Adviser, Science Policy, and Emerging Issues. EEA, Copenhagen, 25 February, 2011

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David Gee on Late Lessons from Early Warnings: Toward Realism and Precaution with EMF, and by Sage and Carpenter on Public Health Implications.

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Institute for Health and the Environment
WHO Collaborating Center in Environmental Health

17 July 2012

L. MORGAN EXHIBIT L

Smart Meters: Correcting the Gross Misinformation

We, the undersigned are a group of scientists and health professionals who together have coauthored hundreds of peer-reviewed studies on the health effects of electromagnetic fields (EMFs). We wish to correct some of the gross misinformation found in the letter regarding wireless "smart" meters that was published in the Montreal daily *Le Devoir* on May 24. Submitted by a group Quebec engineers, physicists and chemists, the letter in question reflects an obvious lack of understanding of the science behind the health impacts of the radiofrequency (RF)/microwave EMFs emitted by these meters.

The statement that "Thousands of studies, both epidemiological and experimental in humans, show no increase in cancer cases as a result of exposure to radio waves of low intensity..." is false[1]. In fact, only a few such studies — perhaps a dozen, certainly not thousands, have reported no elevations of cancer, and most were funded by the wireless industry. In addition, these reassuring studies contained significant experimental design flaws, mainly the fact that the populations followed were too small and were followed for a too short period of time.

Non industry-funded studies have clearly demonstrated a significant increase in cancer cases among individuals who have suffered from prolonged exposure to low-level microwaves, transmitted notably by radio antennas. The effects were best documented in meta-analyses that have been published and that include grouped results from several different studies: these analyses consistently showed an increased risk of brain cancer among regular users of a cell phone who have been exposed to microwaves for at least ten years.

Brain Cancer Rates

Furthermore, the argument that brain cancer rates do not indicate an overall increase in incidence is not evidence that cell phones are safe: the latency for brain cancer in adults after environmental exposure can be long, up to 20-30 years. Most North Americans haven't used cell phones extensively for that long. The evidence of the link between long-term cell phone use and brain cancer comes primarily from Northern Europe, where cell phones have been commonly used since the 1990s.

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Children are especially at risk. In May 2012, the U.K.'s Office of National Statistics reported a 50 percent increase in incidence of frontal and temporal lobe tumors in children between 1999 and 2009. This statistic is especially disturbing since in May 2011, after reviewing the published scientific literature regarding cancers affecting cell phone users, the International Agency for Research on Cancer (IARC) classified radiofrequency radiation as a 2B, *possible human carcinogen*. Despite the absence of scientific consensus, the evidence is sufficiently compelling for any cautious parent to want to reduce their loved one's exposure to RF/microwave emissions as much as possible, as recommended by various countries such as Austria, Belgium, Germany, Russia and the United Kingdom.

Electrosensitivity

Public fears about wireless smart meters are well-founded. They are backed by various medical authorities such as the Public Health Departments of Santa Cruz County (California) and of Salzburg State (Austria). These authorities are worried about the growing number of citizens who say they have developed electrohypersensitivity (EHS), especially since for many of them, the symptoms developed after the installation of such meters (it takes some time for most people to link the two events).

Since the turn of the millennium, people are increasingly affected by ambient microwaves due to the growing popularity of wireless devices such as cell phones and Wi-Fi Internet. Therefore, the mass deployment of smart grids could expose large chunks of the general population to alarming risk scenarios without their consent. According to seven surveys done in six European countries between 2002 and 2004, about 10% of Europeans have become electrosensitive, and experts fear that percentage could reach 50% by 2017. The most famous person to publicly reveal her electrosensitivity is Gro Harlem Brundtland, formerly Prime Minister of Norway and Director of the World Health Organization (WHO).

While there is no consensus on the origins and mechanisms of EHS, many physicians and other specialists around the world have become aware that EHS symptoms (neurological dermatological, acoustical, etc.) seem to be triggered by exposure to EMF levels well below current international exposure limits, which are established solely on short-term thermal effects (2). Organizations such as the Austrian Medical Association and the American Academy of Environmental Medicine have recognized that the ideal way to treat of EHS is to reduce EMF exposure.

Therefore, caution is warranted because the growing variety of RF/microwave emissions produced by many wireless devices such as smart meters have never been tested for their potential biological effects.

Well-known bioeffects

While the specific pathways to cancer are not fully understood, it is scientifically unacceptable to deny the weight of the evidence regarding the increase in cancer cases in humans that are exposed to high levels of RF/microwave radiation.

The statement that "there is no established mechanism by which a radio wave could induce an adverse effect on human tissue other than by heating" is incorrect, and reflects a lack of awareness and understanding of the scientific literature on the subject. In fact, more than a thousand studies done on low intensity, high frequency, non-ionizing radiation, going back at least fifty years, show that some biological mechanisms of effect do not involve heat. This radiation sends signals to living tissue that stimulate biochemical changes, which can generate various symptoms and may lead to diseases such as cancer.

Even though RF/microwaves don't have the energy to directly break chemical bonds, unlike ionizing radiation such as X-rays, there is scientific evidence that this energy can cause DNA damage indirectly leading to cancer by a combination of biological effects. Recent publications have documented the generation of free radicals, increased permeability of the blood brain barrier allowing potentially toxic chemicals to enter the brain, induction of genes, as well as altered electrical and metabolic activity in human brains upon application of cell phone RF/microwaves similar to those produced by smart meters.

These effects are cumulative and depend on many factors including RF/microwave levels, frequency, waveform, exposure time, biovariability between individuals and combination with other toxic agents. Clear evidence that these microwaves are indeed bioactive has been shown by the fact that low-intensity EMFs have proven clinically useful in some circumstances. Pulsed EMFs have long been used to successfully treat bone fractures that are resistant to other forms of therapy. More recently, frequency-specific, amplitude-modulated EMFs have been found useful to treat advanced carcinoma and chronic pain.

High frequency EMFs such as the microwaves used in cell phones, smart meters, Wi-Fi and cordless "DECT" phones, appear to be the most damaging when used commonly. Most of their biological effects, including symptoms of electrohypersensitivity, can be seen in the damage done to cellular membranes by the loss of structurally-important calcium ions. Prolonged exposure to these high frequencies may eventually lead to cellular malfunction and death.

Furthermore, malfunction of the parathyroid gland, located in the neck just inches from where one holds a cell phone, may actually cause electrohypersensitivity in some people by reducing the background level of calcium ions in the blood. RF/microwave radiation is also known to decrease the production of melatonin, which protects against cancer, and to promote the growth of existing cancer cells.

Early warning scientists attacked

In recommending that the Precautionary Principle be applied in EMF matters, the European Environment Agency's Director Jacqueline McGlade wrote in 2009: "We have noted from previous health hazard histories such as that of lead in petrol, and methyl mercury, that 'early warning' scientists frequently suffer from discrimination, from loss of research funds, and from unduly personal attacks on their scientific integrity. It would be surprising if this is not already a feature of the present EMF controversy..." Such unfortunate consequences have indeed occurred.

The statement in the *Le Devoir* letter that "if we consider that a debate should take place, it should focus exclusively on the effects of cell phones on health" is basically an acknowledgement that there is at least some reason to be concerned about cell phones. However, while the immediate exposure from a cell phone is of much greater intensity than the exposure from smart meters, cell phone use is temporary.

Smart meters

Wireless smart meters typically produce atypical, relatively potent and very short pulsed RF/microwaves whose biological effects have never been fully tested. They emit these millisecond-long RF bursts on average 9,600 times a day with a maximum of 190,000 daily transmissions and a peak level emission two and a half times higher than the stated safety signal, as the California utility Pacific Gas & Electric recognized before that State's Public Utilities Commission. Thus people in proximity to a smart meter are at risk of significantly greater aggregate exposure than with a cell phone, not to mention the cumulative levels of RF/microwaves that people living near several meters are exposed to.

People are exposed to cell phone microwaves primarily in the head and neck, and only when they use their device. With smart meters, the entire body is exposed to the microwaves, which increases the risk of overexposure to many organs.

In addition to these erratic bursts of modulated microwaves coming from smart meters that are transferring usage data to electric, gas and water utilities, wireless and wired smart (powerline communication) meters are also a major source of ''dirty electricity'' (electrical interference of high frequency voltage transients typically of kilohertz frequencies). Indeed, some scientists, such as American epidemiologist Sam Milham, believe that many of the health complaints about smart meters may also be caused by dirty electricity generated by the « switching » power supply activating all smart meters. Since the installation of filters to reduce dirty electricitv circulating on house wiring has been found to relieve symptoms of EHS in some people, this method should be considered among the priorities aimed at reducing potential adverse impacts.

Rather be safe than sorry

The apparent adverse health effects noted with smart meter exposure are likely to be further exacerbated if smart appliances that use wireless communications become the norm and further increase unwarranted exposure.

To date, there have been few independent studies of the health effects of such sources of more continuous but lower intensity microwaves. However, we know after decades of studies of hazardous chemical substances, that chronic exposure to low concentrations of microwaves can cause equal or even greater harm than an acute exposure to high concentrations of the same microwaves.

This is why so many scientists and medical experts urgently recommend that measures following the Precautionary Principle be applied immediately — such as using wired meters — to reduce biologically inappropriate microwave exposure. We are not advocating the abolishment of RF technologies, only the use of common sense and the development and implementation of best practices in using these technologies in order to reduce exposure and risk of health hazards.

1. Scientific papers on EMF health effects

2. Explanation and studies on electrosensitivity

3. Governments and organizations that ban or warn against wireless technology

• David O. Carpenter, MD, Director, Institute for Health & the Environment, University at Albany, USA

• Jennifer Armstrong, MD, Past President, Canadian Society of Environmental Medicine, Founder, Ottawa Environmental Health Clinic, Ontario, Canada

• Fiorella Belpoggi, Director *Cesare Maltoni* Cancer Research Center, Ramazzini Institute, Bologna, Italy

• Martin Blank, PhD, former President, Bioelectromagnetics Society, Special Lecturer, Department of Physiology and Cellular Biophysics, Columbia University Medical Center, New York, USA

• Barry Breger, MD, Centre d'intégration somatosophique (orthomolecular medicine), Montreal, Quebec

• John Cline, MD, Professor, Institute for Functional Medicine, Federal Way, WA, USA, Medical Director, Cline Medical Centre, Nanaimo, BC, Canada

• Alvaro Augusto de Salles, PhD, Professor of Electrical Engineering, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

• Christos Georgiou, Prof. Biochemistry, Biology Department, University of Patras, Greece

• Claudio Gómez-Perretta, MD, PhD, Director, Centro de Investigación, Hospital Universitario LA Fe, Valencia, Spain

• Livio Giuliani, PhD, Senior Researcher, National Insurance Institute (INAIL), Chief of Radiation and Ultrasounds Research Unit, Rome, Italy

• Yury Grigoriev, PhD, Chair Russian National Committee on Non-Ionizing Radiation Protection, Moscow, Russia

• Settimio Grimaldi, PhD, Director, Institute of Translational Pharmacology (Neurobiology and molecular medicine), National Research Council, Rome, Italy

• Magda Havas, PhD, Centre for Health Studies, Trent University, Canada

• Lennart Hardell, MD, Professor of Oncology, University Hospital, Örebro, Sweden

• Denis L. Henshaw, PhD, Professor of Physics, Head of The Human Radiation Effects Group, University of Bristol, UK

• Ronald B. Herberman, MD, Chairman of Board, Environmental Health Trust, and Founding Director emeritus, University of Pittsburgh Cancer Institute, USA

• Isaac Jamieson, PhD Environmental Science (electromagnetic phenomena in the built environment), independent architect, scientist and environmental consultant, Hertfordshire, UK

• Olle Johansson, PhD, Professor of Neuroscience (Experimental Dermatology Unit), Karolinska Institute, Stockholm, Sweden

• Yury Kronn, PhD, Soviet authority on physics of nonlinear vibrations and high frequency electromagnetic vibrations, founder of Energy Tools International, Oregon, USA

• Henry Lai, PhD, Professor of Bioengineering, University of Washington School of Medicine, Seattle, WA, USA

• Abraham R. Liboff, PhD, Professor Emeritus, Department of Physics, Oakland University, Rochester, Michigan, USA

• Don Maisch, PhD, Researcher on radiation exposure standards for telecommunications frequency, EMFacts Consultancy, Tasmania, Australia

• Andrew A. Marino, MD, PhD, JD, Professor of Neurology, LSU Health Sciences Center, Shreveport, LA, USA

• Karl Maret, MD, M.Eng., President, Dove Health Alliance, Aptos, CA, USA

• Sam Milham, MD, former chief epidemiologist, Washington State Department of Health, USA

• Joel M. Moskowitz, PhD, Director, Center for Family and Community Health, School of Public Health, University of California, Berkeley

• Gerd Oberfeld, MD, Public Health Department, Salzburg State Government, Austria

• Jerry L. Phillips, PhD, Director, Center for Excellence in Science, Department of Chemistry and Biochemistry, University of Colorado, USA

• William J. Rea, MD, thoracic and cardiovascular surgeon, founder of the Environmental Health Center, Dallas, Tx, USA

• Elihu D. Richter, MD, Professor, Hebrew University-Hadassah School of Public Health and Community Medicine, Jerusalem, Israel

• Cyril W. Smith PhD, lead author of "Electromagnetic Man", retired from Electronic and Electrical Engineering, University of Salford, UK

• Morando Soffritti, MD, Scientific Director of the European Foundation for Oncology and Environmental Sciences "B. Ramazzini" in Bologna, Italy

• Antoinette "Toni" Stein, PhD, Collaborative on Health and the Environment (CHE-EMF Working Group), Co-Coordinator, Berkeley, CA, USA

• Stanislaw Szmigielski, MD, PhD Professor of Pathophysiology, Consulting Expert, former director of Microwave Safety, Military Institute of Hygiene and Epidemiology, Warsaw, Poland

• Bradford S. Weeks, MD, The Weeks Clinic, Clinton, WA, USA

• Stelios A. Zinelis, MD, Vice-President, Hellenic Cancer Society, Cefallonia, Grece

Coordination: André Fauteux, Publisher and Editor in chief, la Maison du 21e siècle magazine, Sainte-Adele, Quebec, Canada.

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L. MORGAN
EXHIBIT M

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January 19, 2012

Decision Proposed Decision of Commissioner Peevy (Mailed 11/22/2011)
BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA
On the proposed decision 11-03-014

Dear Commissioners:

The Board of the American Academy of Environmental Medicine opposes the installation of wireless "smart meters" in homes and schools based on a scientific assessment of the current medical literature (references available on request). Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action.

As representatives of physician specialists in the field of environmental medicine, we have an obligation to urge precaution when sufficient scientific and medical evidence suggests health risks which can potentially affect large populations. The literature raises serious concern regarding the levels of radio frequency (RF - 3KHx – 300 GHx) or extremely low frequency (ELF – 0Hx – 300Hx) exposures produced by "smart meters" to warrant an immediate and complete moratorium on their use and deployment until further study can be performed. The board of the American Board of Environmental Medicine wishes to point out that existing FCC guidelines for RF safety that have been used to justify installation of "smart meters" only look at thermal tissue damage and are obsolete, since many modern studies show metabolic and genomic damage from RF and ELF exposures below the level of intensity which heats tissues. The FCC guidelines are therefore inadequate for use in establishing public health standards. More modern literature shows medically and biologically significant effects of RF and ELF at lower energy densities. These effects accumulate over time, which is an important consideration given the chronic nature of exposure from "smart meters". The current medical literature raises credible questions about genetic and cellular effects, hormonal effects, male fertility, blood/brain barrier damage and increased risk of certain types of cancers from RF or ELF levels similar to those emitted from "smart meters". Children are placed at particular risk for altered brain development, and impaired learning and behavior. Further, EMF/RF adds synergistic effects to the damage observed from a range of toxic chemicals. Given the widespread, chronic, and essentially inescapable ELF/RF exposure of everyone living near a "smart meter", the Board of the American Academy of Environmental Medicine finds it unacceptable from a public health standpoint to implement this technology until these serious medical concerns are resolved. We consider a moratorium on installation of wireless "smart meters" to be an issue of the highest importance.

The Board of the American Academy of Environmental Medicine also wishes to note that the US NIEHS National Toxicology Program in 1999 cited radiofrequency radiation as a potential carcinogen. Existing safety limits for pulsed RF were termed "not protective of public health" by the Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others). Emissions given off by "smart meters" have been *classified by the World Health Organization International Agency for Research on Cancer (IARC) as a Possible Human Carcinogen.*

Hence, we call for:

- An immediate moratorium on "smart meter" installation until these serious public health issues are resolved. Continuing with their installation would be extremely irresponsible.

- Modify the revised proposed decision to include hearings on health impact in the second proceedings, along with cost evaluation and community wide opt-out.

- Provide immediate relief to those requesting it and restore the analog meters.

Members of the Board
American Academy of Environmental Medicine

L. MORGAN
EXHIBIT N

International Doctors´ Appeal 2012

10 Years after the Freiburg Appeal:

Radio-frequency Radiation Poses a Health Risk. Physicians Demand Overdue Precaution.

More than 1000 physicians signed the "Freiburg Appeal" in 2002. It was translated into many languages. As many as 36,000 people from all over the world support its warning about the dangers of radio-frequency radiation. Today—ten years later—we as physicians and scientists call again on our colleagues and the wider global community, but also on all politicians around the world.

I. Evidence:

Despite all warnings, more and more **new wireless technologies** are introduced into our daily lives: cell phone networks, TETRA, LTE, cordless phones, Wi-Fi, baby monitors, wireless meters, digital radio and TV, and many others. All of these wireless technologies interfere with the biophysical organization of life with increasing layers and densities of electromagnetic fields.

Human, animal, and plant life is controlled by naturally occurring electromagnetic fields and signals. With their extremely low to very high frequencies, technical electromagnetic fields can interfere strongly with cell communication and metabolism. Initially, the body's natural healing capacity, in its attempt to maintain homeostasis, will correct imbalances through finely tuned control mechanisms. Prolonged electromagnetic stress, however, may lead to a chronic impairment of this important homeostatic response and result in disease.

Scientific studies repeatedly demonstrate that electromagnetic fields can **impair self-regulation** and cause adverse biological impacts, including: increased permeability of the protective blood-brain barrier, changes in brain wave activity, unbalanced release of neurotransmitters and hormones (especially the increase in stress hormones), immune system impairment, damage to genetic material, and lowered fertility, to name only a few of the well-established examples. Oxidative cell stress—a major cause of many diseases—has been shown to be a central effect mechanism of radiation exposure.

A number of pressing **mental health disorders appear to be increasing** at a worrisome rate, including depression, burnout syndrome as well as sleep, anxiety, and panic disorders. This is also evident for a number of other diseases: stroke in younger people, degenerative neurological disorders (e.g. early onset of dementia syndromes), headaches, tinnitus, autism, learning disorders, concentration problems, and behavioral disorders (ADHD) Empirical observations suggest that the increase in radio-frequency radiation exposures counts among the crucial environmental factors that are responsible for a steady increase in allergies, skin problems, pain syndromes, susceptibility to infections, high blood pressure, cardiac arrhythmias, metabolic disorders, and multi-system disorders.

Observable patterns of **temporal and spatial relationships** between the onset of these symptoms and disorders and the start of an exposure to electromagnetic fields (e.g. in the vicinity of a newly installed cell tower or after heavy cell phone use) suggest that they are causally related. The association between cell phone/cordless phone use and a clear increase in brain tumors has been repeatedly documented in the scientific literature.

Children and adolescents are most vulnerable. After leukemia, brain tumors are the second most common cancer in children. In Europe the cancer rate among adolescents has increased 1.5 percent each year. In England frontal and temporal lobe tumors in children rose significantly from 1999 to 2009. And children increasingly display addictive behavior in the use of their cell phones and other online devices. Numerous appeals and resolutions, therefore, call for the special protection of children and adolescents, as, for instance, the European Environment Agency did in the fall of 2011.

The number of those who suffer from **electrohypersensitivity** is steadily growing. In those who are affected, severe symptoms to electromagnetic fields can develop immediately or hours after the exposure to technical electromagnetic fields. Sweden has recognized electrohypersensitivity as a functional impairment. The European Parliament has called on its member states "to follow the example of Sweden," and U.S. State Governors have raised public awareness about the serious consequences of electrohypersensitivity. The Austrian Medical Association has released a guideline for the diagnosis and treatment of EMF-related health problems and illnesses.

Health care professionals worldwide make observations that are consistent with and increasingly confirmed by **scientific findings. Adverse effects** of electromagnetic fields and the fundamental impairment of biological control mechanisms can occur well below current exposure limits and have been demonstrated, in some instances for decades. The international BioInitiative Working Group (2007) documented a broad range of health risks based on more than 1500 scientific studies. Since then numerous studies have confirmed the worrisome results and shown that current exposure limits that only consider damage caused by thermal effects are inadequate. The **World Health Organization** (WHO) classified RF radiation as possibly carcinogenic in May 2011 based on the increased risk of brain tumors among those who heavily use their cell phones for many years. And market-leading manufacturers of cell phones corroborate the association when they justify their patent applications with the argument of cancer risk.

In **numerous appeals and resolutions over the past years,** a growing number of expert scientists and physicians have pointed to the health risks associated with radio-frequency radiation exposures. In 2008 the Russian Radiation Protection Committee RNCNIRP gave a warning about the **serious** and **irreparable consequences** of electromagnetic radiation especially for children, and again in 2011, intensified its warning. The European Environment Agency called for urgent precautionary action in 2009. The European Parliament repeated this call also in 2009.

In a unanimous resolution in 2011, the European Council demands abandoning wireless communication policies that are seen as unsustainable in their current form.

II. Appeal:

As physicians and scientists, we hereby call on our colleagues; on the leaders of federal, state, and local governments; but also on the wider community to take action and implement the following precautionary strategies, which also include fundamental human rights:

1. Protect the inviolability of the home by minimizing radio-frequency exposure levels, which penetrate through the walls of one's own home.
2. Ensure considerably lower radio-frequency radiation exposures as well as exposure limits that reliably protect humans and nature from adverse biological effects of electromagnetic fields. Any further expansion of wireless technologies is irresponsible.
3. Prefer wired solutions for home use and public institutions, especially at preschools, schools, colleges, universities, nursing homes, and hospitals.
4. Cutback and reprogram continuously emitting devices such as cordless phones, wireless Internet access (Wi-Fi), and wireless smart meters so that they only operate and emit radio-frequency radiation on demand when being used.
5. Provide special protection for children and adolescents: Children below the age of 8 should not use cell phones and cordless phones; children and adolescents between the ages 8 and 16 should also not use cell phones or only use them in the case of an emergency. Devices for mobile and wireless communication for children and adolescents may not be advertised.
6. Attach clearly visible warning labels and safety guidelines for lowering the radiation exposure on cell phones and other wireless devices, including instruction manuals. An important reminder: do not carry a cell phone right next to your body when it is turned on.
7. Identify and clearly mark protected zones for electrohypersensitive people; establish public areas without wireless access or coverage, especially on public transport, similar to smoke-free areas for nonsmokers.
8. Promote the development of communication technologies and electricity use that is more compatible with health. Prefer wired solutions for home use and public facilities. Expand fiber-optic networks as the foundation of a modern, sustainable, and performance-based technology that meets the ever-increasing demand for higher data transmission rates.
9. Provide government funding for industry-independent research and education that do not dismiss strong scientific and medical findings of potential risks, but rather work to clarify those risks.

At the same time, we also call on everyone who cares about health and the environment: Make wise consumer choices and thus help reduce exposure levels. Favor wired communication technologies. Inform yourself and pass this knowledge on to your family, neighbors, friends, and politicians. Get involved and make a difference so that the protection of human health and the environment is not left to and limited by commercial interests.

Signers: (Please complete in block letters, Thanks)

Last Name, First Name	Title	Occupation	Address: Country Place, Zip Code; Street, House No.	Email /Fax*	Signature
1.					
2.					
3.					

Guideline of the Austrian Medical Association (ÖÄK) for the diagnosis and treatment of EMF-related health problems and illnesses (EMF syndrome)

Consensus paper of the Austrian Medical Association's EMF Working Group (ÖÄK AG-EMF)

Adopted at the meeting of environmental medicine officers of the Regional Medical Association´s and the Austrian Medical Association on 3rd March 2012 in Vienna.

Introduction

There has been a sharp rise in unspecific, often stress-associated health problems that increasingly present physicians with the challenge of complex differential diagnosis. A cause that has been accorded little attention so far is increasing electrosmog exposure at home, at work and during leisure activities, occurring in addition to chronic stress in personal and working life. It correlates with an overall situation of chronic stress that can lead to burnout.

How can physicians respond to this development?

The Austrian Medical Association has developed a guideline for differential diagnosis and potential treatment of unspecific stress-related health problems associated with electrosmog. Its core element is a patient questionnaire consisting of a general assessment of stress symptoms and a specific assessment of electrosmog exposure.

The guideline is intended as an aid in diagnosing and treating EMF-related health problems.

Background

Many people are increasingly exposed, to various degrees, to a combination of low and high frequency electric fields (EF), magnetic fields (MF) and electromagnetic fields (EMF) of different signal patterns, intensities and technical applications for varying periods of time, colloquially referred to as electrosmog.

Physicians are often confronted with unspecific complaints without clearly identifiable causes (Huss and Röösli 2006). It has been suspected that environmental conditions such as increasing exposure of the population to radio waves, emanating e.g. from cordless phones, mobile phone base stations, cell phones, GPRS, UMTS, data cards for laptop and notebook computers and wireless LAN (WLAN), but also exposure to electric and magnetic fields emanating from power lines, devices and equipment, may play a causal role (Blake Levitt and Lai 2010). For the medical profession, this raises new challenges in diagnosis and treatment. A central issue for

the causal attribution of symptoms is the assessment of variation in health problems depending on time and location, which is particularly relevant for environmental causes such as EMF exposure.

Austria is currently rolling out the fourth generation of mobile telephony (LTE), as well as smart metering (for electricity, gas and water consumption), resulting in additional EMF exposure of the population.

New radio technologies and applications have been introduced without certainty about their health effects, raising new challenges for medicine. For instance, the issues of so-called non-thermal effects and potential long-term effects of low-dose exposure were hardly investigated at all prior to introduction. Some patients suspect a link between EMF exposure and their health problems. Moreover, physicians are increasingly confronted with health problems with unidentified causes. Pursuing an evidence-based treatment strategy in this context is a challenge for differential diagnosis.

In Austria, there are no democratically legitimized limits to protect the general population from EMF exposure. The recommendations of the WHO, compiled by the International Commission on Non-Ionizing Radiation Protection (ICNIRP 1998), are based on a thermal model. These recommendations were adopted by the EU in its Council Recommendation of 1999 (EU-Ratsempfehlung 1999) and by Austria in its pre-standard ÖVE/ÖNORM E 8850:2006 02 01 (ÖNORM 2006) without taking into account long-term non-thermal effects.

In August 2007, the BioInitiative, an international group of experts, published a comprehensive report calling for preventive measures against EMF exposure based on the scientific evidence available (BioInitiative 2007). Consequently, the European Environment Agency compared electrosmog to other environmental hazards such as asbestos or benzene (EEA 2007).

In April 2009, a resolution of the European Parliament called for a review of the EMF limits in the EU Council Recommendation of 1999, which was based on the guidelines of the ICNIRP, with reference to the BioInitiative Report (EU Parliament 2009).

In May 2011, the Parliamentary Assembly of the Council of Europe adopted the report "The potential dangers of electromagnetic fields and their effect on the environment" (PACE 2011). The report calls for a number of measures to protect humans and the environment, especially from high-frequency electromagnetic fields. One of the recommendations is to "take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumours".

Also in May 2011, a group of experts at the International Agency for Research on Cancer, an agency of the WHO, classified radiofrequency electromagnetic fields as possibly carcinogenic (Group 2B) for humans (IARC 2011).

A representative telephone survey (n=2048, age >14 years) carried out in 2004 in Switzerland yielded a frequency of 5% (95% CI 4-6%) for a self-attributed "diagnosis" of electrosensitivity (Schreier et al. 2006).

In another survey carried out in Switzerland, in 2001, 394 respondents attributed specific health problems to EMF exposure. Among others, the following symptoms were reported as occurring frequently: sleep problems (58%), headaches (41%), nervousness (19%), fatigue (18%) and difficulty concentrating (16%). The respondents listed mobile phone base stations (74%), cell phones (36%), cordless phones (29%) and high-voltage lines (27%) as causes. Two thirds of respondents had taken measures to reduce their symptoms, the most frequent measure being to avoid exposure. Remarkably, only 13% had consulted their physicians (Röösli et al. 2004).

While a 2006 study by Regel et al. described no exposure effects, two provocation studies on exposure of "electrosensitive" individuals and control subjects to mobile phone base station signals (GSM, UMTS or both) found a significant decline in well-being after UMTS exposure in the individuals reporting sensitivity (Zwamborn et al. 2003, Eltiti et al. 2007). Analysis of the data available on exposure of people living near mobile phone base stations has yielded clear indications of adverse health effects (Santini et al. 2002, Navarro et al. 2003, Hutter et al. 2006, Abdel-Rassoul et al. 2007, Blettner et al. 2008).

Based on the scientific literature on interactions of EMF with biological systems, several mechanisms of interaction are possible. A plausible mechanism at the intracellular and intercellular level, for instance, is interaction via the formation of free radicals or oxidative and nitrosative stress (Friedmann et al. 2007, Simkó 2007, Pall 2007, Bedard and Krause 2007, Pacher et al. 2007, Desai et al. 2009). It centres on the increased formation of peroxynitrite ($ONOO^-$) from a reaction of nitrogen monoxide (NO) with superoxide ($O2^-$). Due to its relatively long half-life, peroxynitrite damages a large number of essential metabolic processes and cell components.

This approach can serve as a plausible explanation of many of the health problems, symptoms and their progression observed in the context of EMF exposure. There are increasing indications that EMF syndrome (EMFS) should be counted among multi-system disorders (Pall 2007) such as Chronic Fatigue Syndrome (CFS), Multiple Chemical Sensitivity (MCS), fibromyalgia (FM) and Post Traumatic Stress Disorder (PTSD).

In Sweden, EMF syndrome is designated as electrohypersensitivity (EHS), considered a physical impairment and recognized as a disability. With reference to UN Resolution 48/96, Annex, of 20 December 1993 (UN 1993), local governments grant support to individuals with EHS. Employees with EHS have a right to support from their employers so as to enable them to work despite this impairment. Some hospitals in Sweden provide rooms with low EMF exposure.

The Austrian Medical Association considers it its duty and its mission to provide members of the medical profession with a compilation of the current state of the scientific and political debate from a medical perspective and with specific recommendations for action in this first guideline. The guideline can only be improved by suggestions, criticism and amendments. Due to the rapid development of various technologies, the recommendations need to be adapted on an ongoing basis. We therefore invite all medical professionals to send contributions to the next edition of the guideline to the following email address: post@aerztekammer.at

What to keep in mind when dealing with patients and EMF

In the case of unspecific health problems (see patient questionnaire) for which no clearly identifiable cause can be found, EMF exposure should in principle be taken into consideration as a potential cause, especially if the patient suspects that it may be the cause.

How to proceed if EMF-related health problems are suspected

The recommended approach to diagnosis and treatment is intended as an aid and should, of course, be modified as each individual case requires.

1. History of health problems and EMF exposure
2. Examination and findings
3. Measurement of EMF exposure
4. Prevention or reduction of EMF exposure
5. Diagnosis
6. Treatment

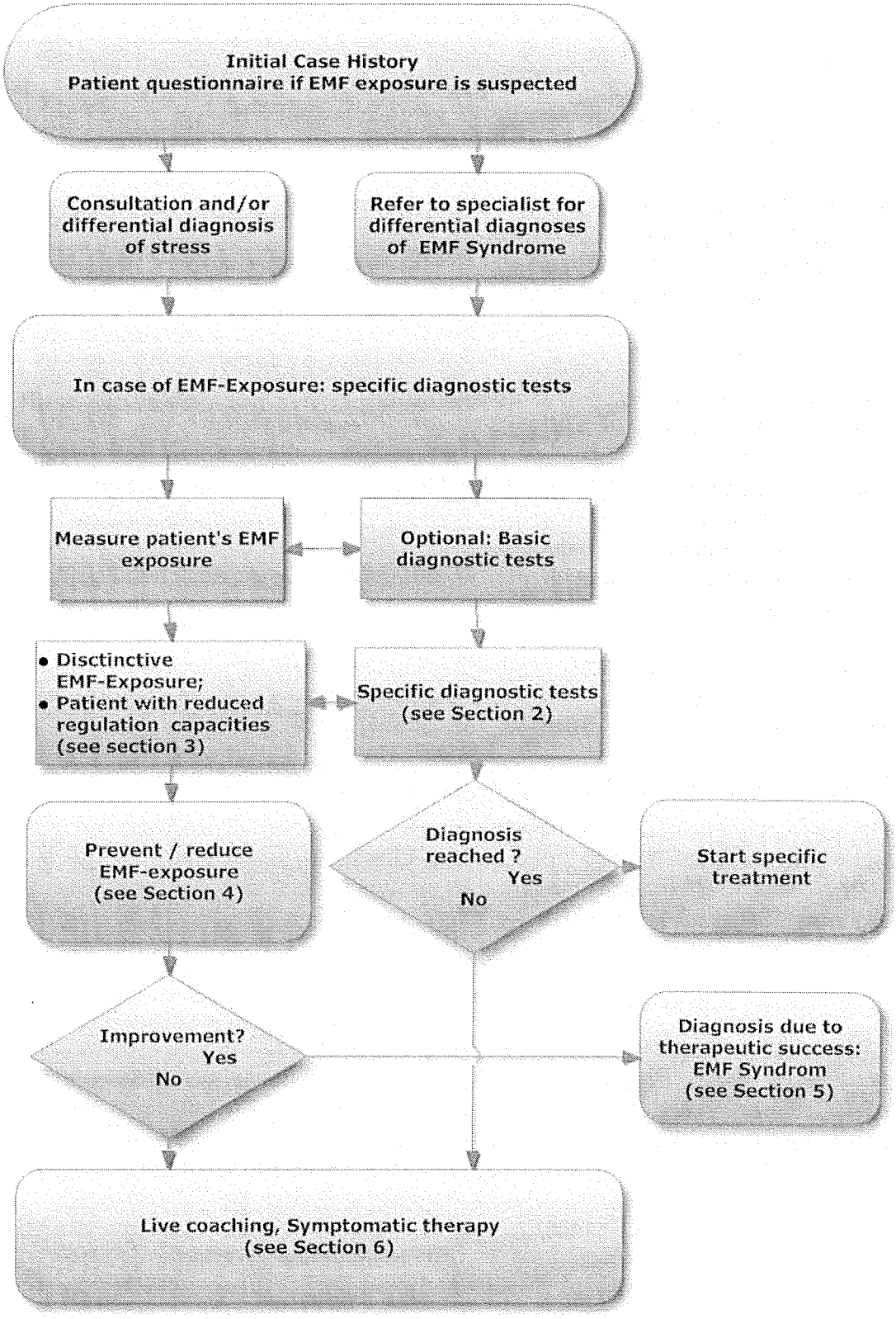

Fig. 1: Flow chart for diagnosing EMF-related health problems

1. History of health problems and EMF exposure

A **patient questionnaire** to facilitate a systematic history of health problems and EMF exposure, compiled by the Austrian Medical Association's EMF Working Group, is available for download at: www.aerztekammer.at/referate Umweltmedizin.

The patient questionnaire consists of three sections:

a) List of symptoms
b) Variation of health problems depending on time and location
c) Assessment of EMF exposure

a) List of symptoms

The list of symptoms in the patient questionnaire serves to systematically quantify stress-related health problems regardless of their causes. It also includes questions on when the health problems first occurred. Most EMF-related symptoms fall within the scope of so-called stress-related health problems, e.g. sleep problems, fatigue, exhaustion, lack of energy, restlessness, heart palpitations, blood pressure problems, muscle and joint pain, headaches, depression, difficulty concentrating, forgetfulness, anxiety, urinary urgency, anomia, dizziness, tinnitus and sensations of pressure in the head and the ears.

The health problems may range in severity from benign, temporary symptoms, such as slight headaches or paraesthesia in the head when using a cell phone, to severe, debilitating symptoms that drastically impair physical and mental health.

b) Variation of health problems depending on time and location

The answers to questions on when and where the health problems occur or recede, and when and where the symptoms increase or are particularly evident, provide indications as to whether the health problems may be related to specific times and locations. They must be interpreted in the context of the patient's living conditions and circumstances.

c) Assessment of EMF exposure

Regardless of whether or not the patient suspects EMF exposure as a cause, these questions should be used to assess the kind of exposure that exists. It is important to note that only certain types of EMF exposure can be assessed by means of the questionnaire, such as use of cell phones and cordless phones. Detection of other types of EMF exposure, e.g. due to high frequency transmitter sites or the electric or magnetic fields of power lines, generally requires measurements (see section 3: Measurement of EMF exposure). In principle, questions should be asked to assess EMF exposure at home and at work, keeping in mind that the degree of EMF exposure may vary at different times.

2. Examination and findings

There are no findings specific to EMF, which makes diagnosis and differential diagnosis a considerable challenge. A method that has proven useful is to use stress-

associated findings for diagnosis and follow-up and to evaluate them synoptically. Basic diagnostic tests should be carried out as a first step, followed by measurements of EMF exposure as a second step. Only then can specific diagnostic tests be considered.

Cardiovascular system

Basic diagnostic tests

- Blood pressure and heart rate (in all cases resting heart rate in the morning while still in bed), including self-monitoring, possibly several times a day, e.g. at different places and with journaling of subjective well-being for a week.

Specific diagnostic tests

- 24-hour blood pressure monitoring (absence of night-time decline)
- 24-hour ECG (heart rhythm diagnosis)
- 24-hour heart rate variability HRV (autonomous nervous system diagnosis)

Laboratory tests

Basic diagnostic tests

- Early morning urine
  - Adrenaline
  - Noradrenaline
  - Noradrenaline/adrenaline quotient
  - Dopamine
  - Serotonin
- Early morning urine
  - 6-OH melatonin sulphate
- Saliva
  - Cortisol (8 am, 12 am and 8 pm)
- Blood
  - Blood count and differential blood count
  - Fasting blood glucose and postprandial blood glucose
  - HBA1c
  - TSH

Additional diagnostic tests – specific individual parameters depending on symptoms

- Late morning urine
  - Histamine, glycine
  - Gamma-aminobutyric acid GABA
  - Glutamate
- Saliva
  - Alpha amylase A (10 am)
  - Dehydroepiandrosterone DHEA (8 am and 8 pm)
- Blood
  - Homocysteine
  - Intracellular ATP

- Intracellular glutathione (redox balance)
- Malondialdehyde (lipid peroxidation)
- 8-hydroxydeoxyguanosine (DNA oxidation)
- Interferon-gamma (IFNg)
- Interleukin-1 (IL-1)
- Interleukin-6 (IL-6)
- Interleukin-10 (IL-10)
- Tumour necrosis factor alpha (TNFa)
- NF-kappaB
- Vitamin B2 (FAD and riboflavin) (whole blood)
- Vitamin B6 (whole blood)
- Vitamin D
- Ubichinon (Q 10)
- Selenium (whole blood)
- Zinc (whole blood)
- Magnesium (whole blood)
- Differential lipid profile

3. Measurement of EMF exposure[1]

In general, a wide variety of forms of EMF exposure (e.g. from cordless phones, wireless internet access, electrical installations and electrical devices in the building, mobile phone base stations, radio and TV transmitters, high-voltage lines or transformer stations) may be the root causes of health problems.

EMF measurements should be planned and carried out by specially trained and experienced measurement engineers.
See e.g. http://www.salzburg.gv.at/adressen_elektrosmog.htm.

After the measurements have been commissioned by the patient and carried out, the results should be discussed with the attending physician or a physician familiar with the issue.

The measurements should be carried out in accordance with relevant standards, e.g. the guidelines of the Professional Association of German Building Biologists (VDB-Richtlinien). In addition to the readings, the measurement report should include suggestions for a potential reduction of exposure.

Basic measurements

Low-frequency alternating magnetic fields

Isotropic magnetic field sensor (for all spatial axes) in the frequency range from 5 Hz to 2 kHz, e.g. near the bed, near the desk with source identification (short-term orientation measurement); in addition, long-term measurements e.g. during the night can be useful.

Low-frequency alternating electric fields

[1] EMF measurements are not covered by statutory health insurance.

Isolated isotropic electric field sensor (for all spatial axes) in the frequency range from 5 Hz to 2 kHz, e.g. near the bed, near the desk with source identification.

High-frequency electromagnetic radiation

Broadband measurements and/or band-selective measurements of common frequencies in the high frequency range, e.g. GSM base stations (900 and 1800 MHz), DECT base stations (1900 MHz), UMTS (2100 MHz), WLAN (2450 and 5000 MHz), possibly WiMAX (3400-3600 MHz), LTE (2500-2700 MHz), within a defined measurement space such as the head and torso area on the bed, or the desk chair, with source identification (e.g. acoustic diagnosis); identification of maximum reading; peak detector.

Additional measurements

High-frequency electromagnetic radiation

Frequency-selective measurements (individual frequencies) of common frequencies in the high frequency range, within a defined measurement space such as the head and torso area on the bed, or the desk chair, with source identification; identification of maximum reading; peak detector. The measurements should be adapted to each individual case, e.g. to account for short-wave transmitters, radar, "dirty power" and other high frequency sources.

Benchmarks

The following aspects should be taken into account when evaluating the readings in each case: duration of exposure, exposure during the night or the day, multiple exposure to different EMF sources, additional exposure to noise, chemicals etc., patient's individual regulation capacity status. Based on epidemiological studies (BioInitiative 2007, Kundi and Hutter 2009) and measurements relevant in practice (Standard of Building Biology Testing Methods, SBM 2008), the Austrian Medical Association 's EMF Working Group has recommended preliminary benchmarks.

Irrespective of the ICNIRP recommendations for acute effects, the following benchmarks apply to regular exposure of more than four hours per day.

High-frequency electromagnetic radiation (as power flow density)

- ≥1000 μW/m² (≥1 mW/m²) — very far above normal
- 10-1000 μW/m² (0.01-1 mW/m²) — far above normal
- 1-10 μW/m² (0.001-0.01 mW/m²) — slightly above normal
- ≤1 μW/m² (≤0.001 mW/m²) — within normal limits

The benchmarks listed are intended to be applied to individual types of radiation, e.g. GSM, UMTS, WiMAX, TETRA, radio, TV, DECT or WLAN, and refer to peak levels. The benchmarks do not apply to radar, which must be evaluated separately. Highly critical types of radiation, such as periodic signals (mobile telephony, DECT, WLAN, digital broadcasting...), should be critically evaluated, especially if levels are far above normal, while less critical types, such as non-pulsed or non-periodic signals (USW, shortwave, medium and long wave, analogue broadcasting), may be considered more leniently.

Low-frequency alternating magnetic fields

- ≥400 nT (≥0.4 μT) — very far above normal
- 100-400 nT (0.1-0.4 μT) — far above normal

- 20-100 nT (0.02-0.1 μT) slightly above normal
- ≤20 nT (≤0.02 μT) within normal limits

The benchmarks are intended to be applied to the range up to and around 50 Hz; higher frequencies and distinct harmonics should be more critically evaluated. Mains current (50 Hz) and traction current (16.7 Hz) should be assessed separately. Long-term measurements should be carried out – also and especially during the night – if intense and frequent field variations occur over time; in such cases, evaluation should be based on the arithmetic mean over the period of exposure.

Low-frequency alternating electric fields

- ≥10 V/m very far above normal
- 1.5-10 V/m far above normal
- 0.3-1.5 V/m slightly above normal
- ≤0.3 V/m within normal limits

The benchmarks (potential-free measurement) are intended to be applied to the range up to and around 50 Hz; higher frequencies and distinct harmonics should be more critically evaluated.

4. Prevention or reduction of EMF exposure

Preventing or reducing EMF exposure after consultation of a measurement engineer is advantageous for several reasons:

a) to prevent and reduce risks to the individual and to public health,
b) to treat the causes of EMF syndrome and
c) to aid in identifying any links to health problems.

There are numerous potential causes for EMF exposure above normal limits, and this guideline can only give a few examples. Further information can be found, for instance, in the building biology checklist "Gebäudecheckliste Baubiologie" (Land Salzburg and VDB 2009) as well as in the information folder on electrosmog (Land Salzburg 2009), which also lists contact data of measurement engineers, sources for measurement devices and materials to reduce exposure. In most cases, it will be necessary to consult an experienced measurement engineer.

Based on documented cases, it is useful to recommend that patients take certain measures (also as preventive measures) to eliminate or reduce EMF exposure, which may lead to an alleviation of health problems within days or weeks. Such measures include the following:

- Disconnecting (unplugging) the power supply of all DECT cordless phones – the use of "classical" cord phones is recommended instead.
- Disconnecting (unplugging) the power supply of all WLAN access points or WLAN routers. (NB: Many LAN routers now come equipped with additional WLAN.)
- Disconnecting the power supply in the bedroom (switching off the fuse) while sleeping. – NB: The benefits should be weighed against the potential risk of accidents and the use of a flashlight should be recommended.
- Disconnecting the power supply to all non-essential electric circuits, possibly in the entire flat or building. NB: See note above.
- Moving the bed or desk to a different place with lower exposure, such as another room or floor; in case of external high frequency sources, rooms facing away from the source should be chosen.
- Discontinuing use of certain appliances and lamps.

- Retrofitting the electrical wiring of the building to reduce residual current and equalising current (installation of a residual current device RCD).

We also recommend following the 10 medical rules for cell phone use published by the Vienna Medical Association :
http://www2.aekwien.at/media/Plakat_Handy.pdf.

5. Diagnosis

A diagnosis of EMF syndrome will largely be based on a comprehensive case history, focusing in particular on correlations between health problems and times and places of EMF exposure, as well as the progression of symptoms over time. In addition, measurements of EMF exposure and the results of additional diagnostic tests (laboratory tests, cardiovascular system) serve to support the diagnosis. Moreover, all other potential causes should be excluded as far as possible.

We recommend that the code Z58.4 (Exposure to radiation) under the International Classification of Diseases (ICD-10) be used for EMF syndrome for the time being.

6. Treatment

The primary method of treatment should consist in the prevention or reduction of EMF exposure, taking care to reduce or eliminate all sources of EMF if possible. Many examples have shown that such measures can prove effective.

Since sufficient EMF reduction is not possible in all cases, other measures can and must be considered. These include not only keeping additional exposure to a minimum, but also enhancing and increasing resistance to EMF. In some cases, positive effects of holistic medicine treatments have been reported.

We take it as given that appropriate treatment will be initiated after diagnosis if the patient presents manifest illness. Regardless of such treatment, the above-mentioned measures to reduce exposure should also be taken.

There is increasing evidence that a main effect of EMF on patients is the reduction of oxidative and nitrosative regulation capacity. This hypothesis also explains observations of changing EMF sensitivity and the large number of symptoms reported in the context of EMF exposure. From the current perspective, it appears useful to recommend a treatment approach such as those gaining ground for multi-system disorders, with the aim of minimizing adverse peroxynitrite effects.

In summary, the following treatment measures appear advantageous, depending on the individual case:

a) **Reduction of exposure** to electric and magnetic fields and high frequency electromagnetic waves.
For more information see e.g. the information folder on electrosmog at www.salzburg.gv.at/infomappe-elektrosmog.pdf.

b) **Lifestyle coaching** (exercise, nutrition, addictive substances, sleeping habits etc.) and stress reduction measures (reduction of general stress and work stress), as well as methods to increase stress resistance (autogenic training, yoga, progressive muscle relaxation, breathing techniques, meditation, tai chi, qui gong).

c) **Holistic treatments** such as anti-oxidative and anti-nitrosative therapies, trace elements, vitamins, amino acids.

d) **Treatment of symptoms** until the causes have been identified and eliminated.

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Download of guidelines and patient questionnaire and contact to the Austrian Medical Association :
www.aerztekammer.at/referate Umweltmedizin

Patient questionnaire

Last name, first name, Mr/Ms .....

Place, date .....

a) List of symptoms

How often have you experienced the following health problems in the past 30 days? Please mark the appropriate box in every line.

Symptoms	Never	Rarely	Sometimes	Often	Very often	If yes, since when (month/year)
Anxiety	☐	☐	☐	☐	☐	/
Tightness in chest	☐	☐	☐	☐	☐	/
Depression	☐	☐	☐	☐	☐	/
Difficulty concentrating	☐	☐	☐	☐	☐	/
Restlessness, tension	☐	☐	☐	☐	☐	/
Hyperactivity	☐	☐	☐	☐	☐	/
Irritability	☐	☐	☐	☐	☐	/
Exhaustion	☐	☐	☐	☐	☐	/
Fatigue	☐	☐	☐	☐	☐	/
Anomia (difficulty finding words)	☐	☐	☐	☐	☐	/
Forgetfulness	☐	☐	☐	☐	☐	/
Headaches	☐	☐	☐	☐	☐	/
Dizziness	☐	☐	☐	☐	☐	/
Sleep problems	☐	☐	☐	☐	☐	/
Noise sensitivity	☐	☐	☐	☐	☐	/
Sensation of pressure in the ears	☐	☐	☐	☐	☐	/
Ear noises, tinnitus	☐	☐	☐	☐	☐	/
Burning sensation in the eyes	☐	☐	☐	☐	☐	/
Nervous bladder, urinary urgency	☐	☐	☐	☐	☐	/
Heart palpitations	☐	☐	☐	☐	☐	/
Blood pressure problems	☐	☐	☐	☐	☐	/
Muscle tension	☐	☐	☐	☐	☐	/
Joint pain	☐	☐	☐	☐	☐	/
Skin conditions	☐	☐	☐	☐	☐	/
Other (please state)	☐	☐	☐	☐	☐	/
Other (please state)	☐	☐	☐	☐	☐	/

b) Variation of health problems depending on time and location

Which health problems do you perceive to be the most severe?	
Since when have you been experiencing these health problems?	
At what times do the health problems occur?	
Is there a place where the health problems increase or are particularly severe? (e.g. at work, at home)	
Is there a place where the health problems recede or disappear altogether? (e.g. at work, at home, other places, at the home of a friend, on holiday, at your weekend home, in the woods)	
Do you have an explanation for these health problems?	
Are you experiencing stress, e.g. due to changes in your personal life or at work?	
Please list any environmental assessments made, measurements or measures taken up to now.	
Please list any environmental medicine diagnoses and treatments given up to now.	
Other	

c) Assessment of EMF exposure at home and at work

1. Do you use a cell phone at home or at work?

How long have you been using it (years/months)? _____
How much do you use it to make calls per day (hours/minutes)? _____
Have you noticed any relation to your health problems?

_____

2. Do you have a cordless phone (DECT base station) at home (H) or at work (W)?

How long have you had it (years/months)? _____
How much do you use it to make calls per day (hours/minutes)? _____
Have you noticed any relation to your health problems?

_____

3. Do you use wireless internet access (WLAN, WiMAX, UMTS) at home (H) or at work (W)?

If yes, how long have you been using it (years/months)? _____
How much do you use it per day (hours/minutes)? _____
Have you noticed any relation to your health problems?

_____

4. Do you use energy-efficient light bulbs in your immediate vicinity (desk lamp, dining table lamp, reading lamp, bedside lamp) at home (H) or at work (W)?

If yes, how long have you been using them (years/months)? _____
For how long are you exposed to them per day (hours/minutes)? _____
Have you noticed any relation to your health problems?

_____

5. Is there a cell tower (mobile phone base station) near your home (H) or your workplace (W)?

If yes, how long has it been there (years/months)? _____
At what distance is it from your home/workplace? _____
Have you noticed any relation to your health problems?

_____

6. Are there any power lines, transformer stations or railway lines near your home (H) or your workplace (W)?

If yes, for how long are you exposed to them per day (hours/minutes)? _____
Have you noticed any relation to your health problems?

_____

6. Do you use Bluetooth devices in your car?

If yes, how long have you been using them? _____
Have you noticed any relation to your health problems?

_____

Parliamentary Assembly
Assemblée parlementaire

COUNCIL OF EUROPE CONSEIL DE L'EUROPE

Parliamentary **Assembly**
Assemblée parlementaire

Resolution 1815 (2011)[1]

The potential dangers of electromagnetic fields and their effect on the environment

1. The Parliamentary Assembly has repeatedly stressed the importance of states' commitment to preserving the environment and environmental health, as set out in many charters, conventions, declarations and protocols since the United Nations Conference on the Human Environment and the Stockholm Declaration (Stockholm, 1972). The Assembly refers to its past work in this field, namely Recommendation 1863 (2009) on environment and health: better prevention of environment-related health hazards, Recommendation 1947 (2010) on noise and light pollution, and more generally, Recommendation 1885 (2009) on drafting an additional protocol to the European Convention on Human Rights concerning the right to a healthy environment and Recommendation 1430 (1999) on access to information, public participation in environmental decision-making and access to justice – implementation of the Århus Convention.

2. The potential health effects of the very low frequency of electromagnetic fields surrounding power lines and electrical devices are the subject of ongoing research and a significant amount of public debate. According to the World Health Organization, electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All populations are now exposed in varying degrees to electromagnetic fields, the levels of which will continue to increase as technology advances.

3. Mobile telephony has become commonplace around the world. This wireless technology relies upon an extensive network of fixed antennae, or base stations, relaying information with radio-frequency signals. Over 1.4 million base stations exist worldwide and the number is increasing significantly with the introduction of third generation technology. Other wireless networks that allow high-speed Internet access and services, such as wireless local area networks, are also increasingly common in homes, offices and many public areas (airports, schools, residential and urban areas). As the number of base stations and local wireless networks increases, so does the radio-frequency exposure of the population.

4. While electrical and electromagnetic fields in certain frequency bands have wholly beneficial effects which are applied in medicine, other non-ionising frequencies, whether from extremely low frequencies, power lines or certain high frequency waves used in the fields of radar, telecommunications and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects and animals as well as the human body, even when exposed to levels that are below the official threshold values.

5. As regards standards or threshold values for emissions of electromagnetic fields of all types and frequencies, the Assembly strongly recommends that the ALARA (as low as reasonably achievable) principle is applied, covering both the so-called thermal effects and the athermic or biological effects of electromagnetic emissions or radiation. Moreover, the precautionary principle should be applied when scientific evaluation does not allow the risk to be determined with sufficient certainty. Given the context of growing exposure of the population, in particular that of vulnerable groups such as young people and children, there could be extremely high human and economic costs if early warnings are neglected.

6. The Assembly regrets that, despite calls for the respect of the precautionary principle and despite all the recommendations, declarations and a number of statutory and legislative advances, there is still a lack of reaction to known or emerging environmental and health risks and virtually systematic delays in adopting and implementing effective preventive measures. Waiting for high levels of scientific and clinical proof before taking action to prevent well-known risks can lead to very high health and economic costs, as was the case with asbestos, leaded petrol and tobacco.

7. Moreover, the Assembly notes that the problem of electromagnetic fields or waves and their potential consequences for the environment and health has clear parallels with other current issues, such as the licensing of medication, chemicals, pesticides, heavy metals or genetically modified organisms. It therefore highlights that the issue of independence and credibility of scientific expertise is crucial to accomplish a transparent and balanced assessment of potential negative impacts on the environment and human health.

8. In light of the above considerations, the Assembly recommends that the member states of the Council of Europe:

8.1. in general terms:

8.1.1. take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumours;

8.1.2. reconsider the scientific basis for the present standards on exposure to electromagnetic fields set by the International Commission on Non-Ionising Radiation Protection, which have serious limitations, and apply ALARA principles, covering both thermal effects and the athermic or biological effects of electromagnetic emissions or radiation;

8.1.3. put in place information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health, especially targeting children, teenagers and young people of reproductive age;

8.1.4. pay particular attention to "electrosensitive" people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network;

8.1.5. in order to reduce costs, save energy, and protect the environment and human health, step up research on new types of antenna, mobile phone and DECT-type device, and encourage research to develop telecommunication based on other technologies which are just as efficient but whose effects are less negative on the environment and health;

8.2. concerning the private use of mobile phones, DECT wireless phones, WiFi, WLAN and WIMAX for computers and other wireless devices such as baby monitors:

8.2.1. set preventive thresholds for levels of long-term exposure to microwaves in all indoor areas, in accordance with the precautionary principle, not exceeding 0.6 volts per metre, and in the medium term to reduce it to 0.2 volts per metre;

8.2.2. undertake appropriate risk-assessment procedures for all new types of device prior to licensing;

8.2.3. introduce clear labelling indicating the presence of microwaves or electromagnetic fields, the transmitting power or the specific absorption rate (SAR) of the device and any health risks connected with its use;

8.2.4. raise awareness on potential health risks of DECT wireless telephones, baby monitors and other domestic appliances which emit continuous pulse waves, if all electrical equipment is left permanently on standby, and recommend the use of wired, fixed telephones at home or, failing that, models which do not permanently emit pulse waves;

8.3. concerning the protection of children:

8.3.1. develop within different ministries (education, environment and health) targeted information campaigns aimed at teachers, parents and children to alert them to the specific risks of early, ill-considered and prolonged use of mobiles and other devices emitting microwaves;

8.3.2. for children in general, and particularly in schools and classrooms, give preference to wired Internet connections, and strictly regulate the use of mobile phones by schoolchildren on school premises;

8.4. concerning the planning of electric power lines and relay antenna base stations:

8.4.1. introduce town planning measures to keep high-voltage power lines and other electric installations at a safe

distance from dwellings;

8.4.2. apply strict safety standards for the health impact of electrical systems in new dwellings;

8.4.3. reduce threshold values for relay antennae in accordance with the ALARA principle and install systems for comprehensive and continuous monitoring of all antennae;

8.4.4. determine the sites of any new GSM, UMTS, WiFi or WIMAX antennae not solely according to the operators' interests but in consultation with local and regional government authorities, local residents and associations of concerned citizens;

8.5. concerning risk assessment and precautions: [1]

8.5.1. make risk assessment more prevention oriented;

8.5.2. improve risk-assessment standards and quality by creating a standard risk scale, making the indication of the risk level mandatory, commissioning several risk hypotheses to be studied and considering compatibility with real-life conditions;

8.5.3. pay heed to and protect "early warning" scientists;

8.5.4. formulate a human-rights-oriented definition of the precautionary and ALARA principles;

8.5.5. increase public funding of independent research, in particular through grants from industry and taxation of products that are the subject of public research studies to evaluate health risks;

8.5.6. create independent commissions for the allocation of public funds;

8.5.7. make the transparency of lobby groups mandatory;

8.5.8. promote pluralist and contradictory debates between all stakeholders, including civil society (Århus Convention).

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[1] . *Text adopted by the Standing Committee*, acting on behalf of the Assembly, on 27 May 2011 (see Doc. 12608, report of the Committee on the Environment, Agriculture and Local and Regional Affairs, rapporteur: Mr Huss).